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HON. BENJAMIN F. TRACY, SECRETARY OF THE NAVY.

THE duties of the Secretary of the Navy of the United States, as defined by Congress, are not only the general superintendence of construction, manning, armament and equipment of vessels of war, but such other duties pertaining to naval matters as may be designated by the President, who is commander-in-chief of both army and navy. During the present administration, the Secretary of the Navy has been one of the busiest of the many busy men in Washington. Not only were new war vessels to be built, but new methods of construction were to be adopted and new materials used, and all had to be subjected to the most careful comparative tests, under the supervision of the Navy Department.

During the summer of 1891 the Navy Department was more active than it has been at any time since the war of the rebellion. The yards were, for several months, kept constantly busy by night as well as by day and upon Sundays and week days alike. The result is the now respectable navy that is fairly equal to the task of maintaining the dignity of the United States upon the high seas.

The administration of the Navy Department under Mr. Tracy has been distinguished for ability and freedom from political partisanship.

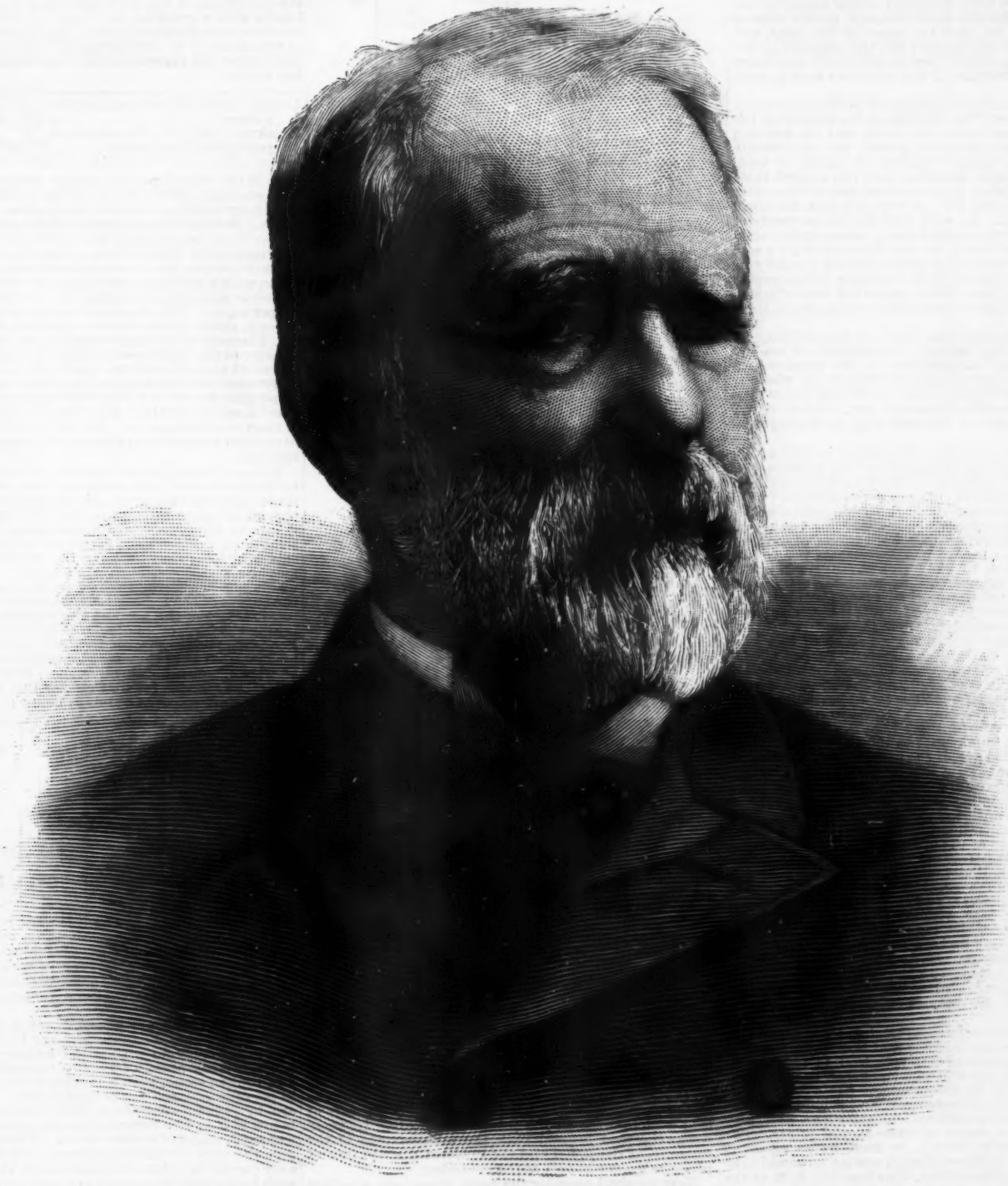
Benjamin F. Tracy, the Secretary of the Navy, was born at Owego, Tioga County, New York, April 26, 1830, and passed his early life upon a farm, receiving the education afforded by the local schools.

He studied law, and was admitted to the bar in 1851, and in 1853 began his political career, being elected District Attorney of Tioga County upon the Whig ticket.

During the war of the rebellion he was active in the Federal service, and organized three regiments, one of which, the 109th New York, he led into the battle of the Wilderness. After that engagement he was made brigadier-general by brevet, and was placed in command of a prison camp and draft rendezvous at Elmira, where he served until the close of the war. He then established a law office in New York, and in 1866 was given the appointment of United States District Attorney for the Eastern District of New York.

General Tracy has never been known as a professional politician. He is a man who is highly regarded by both parties, and his private life is above reproach.

He is still a comparatively young man, and in the full vigor of his intellectual prime.—*The Graphic.*



BENJAMIN F. TRACY, SECRETARY OF THE NAVY.

A NEW kettle has a channel occupying one-third of the bottom. The ordinary heating surface is thus so much increased that the kettle boils more quickly than the ordinary kind.

MASONRY BRIDGES WITH SEMI-FREE JOINTS.*

IT is proposed here to describe the principles and method of construction adopted lately in Germany for masonry bridges, by means of which bridges of large span (150 ft.) have been successfully built with a rise of only one-tenth span at a moderate cost.

The uncertainty which exists as to the position of the "line of resistance" in an arch ring of finite thickness, and the necessity of keeping it well within the thickness of the ring, led to the provision of a ring of greater thickness than is really necessary to mere stability or strength. But, inasmuch as the position of the line of resistance is completely defined for a given loading when three points on it are fixed, provision has been made for defining these points in the case of the metal arch by the introduction of three "semi-free joints" into the arch ring; the amount of play permitted by these joints necessarily entails that every line should pass through them all three, and—by thus at the same time defining the line of resistance—renders it easy to arrange an arch ring which shall contain that line everywhere well within its thickness; these joints are conveniently placed, one at the crown and one at each haunch. The desirability of extending this principle to the masonry arch ring appears to be a suggestion of Mr. Dupuit's; to effect this he proposed to open the joints of rupture at the intrados, using if necessary very hard stone for the voussoirs composing those joints, or even protecting their beds with metal guards.

Other engineers have proposed either rounding the surface of the bed of the upper stone of such a joint or else rounding it off near the edges of the joint, and leaving it plane at the center; but the pressure at the point of rotation would then be too great, and there would be risk of fracture of the voussoirs next to such a reduced joint.

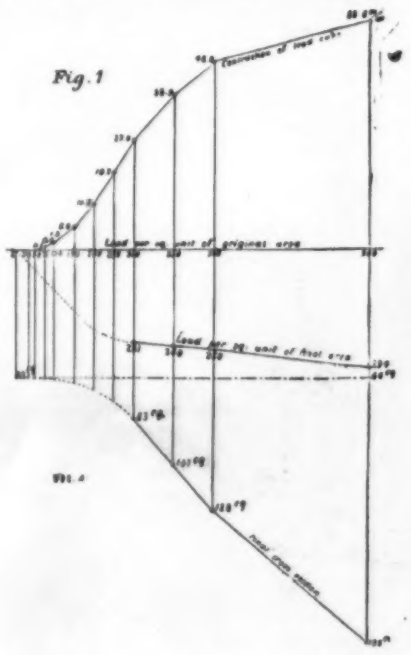
A new method has been introduced by Mr. Leibbrand, royal "Oberbaurath" at Stuttgard, for rendering the three joints in question (at the crown and the joints of rupture near the haunches) somewhat like imperfectly free joints. The "joint" consists of sheets of lead, from $\frac{1}{16}$ to $\frac{1}{8}$ in. thick, covering only the central third of the full bed joint, the remaining spaces (the outer third and inner third, *i. e.*, at extrados and intrados) being left unfilled. As such lead has the property of yielding laterally when under heavy pressure, but without losing its continuity, he has thus contrived a sort of rudimentary articulation which has the property (as will be presently explained) of confining within pretty narrow limits the zone within which the line of resistance can suffer displacement under any mode of loading whatever.

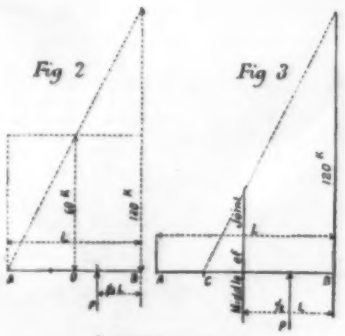
In order to make clear the merit of this method, let us consider first the manner of resistance of lead to crushing, and the admissibility of its employment under similar conditions, and next the mode whereby Mr. Leibbrand diminishes what would appear at first sight to be a serious disadvantage, viz., that of reduction of the thickness of the arch ring to one-third at those places.

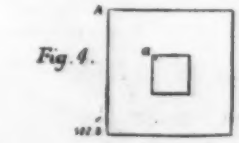
The following experiments were made in 1885 at the Polytechnic School at Stuttgard on the resistance of lead to crushing (see Fig. 1). It was found that ordinary cast lead in the shape of cubes of 8 centimeters (=3·15 in). side and specific gravity of 11·3 could bear a load of 50 kilogrammes per square centimeter for twenty-six hours without showing any indications of bulging laterally. Under a load of 72 kilogrammes per square centimeter it begins to yield slowly. Increasing the load every ten minutes up to 300 kilogrammes per square centimeter of the original area, the horizontal section did not increase very rapidly; it increased from 64 to 83 square centimeters, while the load per square unit of the final area is only 231 (in place of 300) kilogrammes. From 300 to 900 kilogrammes per square centimeter of the original area the horizontal section increased so rapidly that the load per square unit of the final area changed but little; it increased from 231 to 294 kilogrammes per square centimeter; so may be considered nearly constant (see Fig. 1). This property of lead is of great importance in the point of view now under consideration; for if the line of resistance should approach near the edge of the lead plate, the pressure would then exceed the crushing resistance of the metal, so that it would immediately yield at the point of greatest pressure until the pressure per square unit was reduced to the proper amount.

Disks of cast lead of 16 centimeters (=6·3 in.) diameter and 15 millimeters (=0·59 in.) thickness, similar to the joints of 20 to 22 millimeters (=$\frac{3}{4}$ in. to $\frac{7}{8}$ in.), used in bridges, offer a much greater resistance to crushing than the 8 centimeter (=3·15 in.) cubes previously mentioned; they bear without yielding a permanent load of 100 kilogrammes per square centimeter, and begin yielding slowly under a load of 150 kilogrammes per square centimeter. Hard lead cubes of 8 centimeters (=3·15 in.) side bear much larger loads; they sustain a permanent load of 250, and begin yielding under a load of 300 kilogrammes per square centimeter.

The Stuttgard experiments certainly leave something to be cleared up; but it seems that it may be accepted from them that sheets of cast soft lead 15 to 20 millimeters (=0·59 in. to 0·79 in.) thick can bear without yielding a load of 120 kilogrammes per square centimeter (=1,706 lb. per square inch), and it is on this basis that the German engineers calculate the necessary width for the lead sheets of these special joints. The width of these strips should, in fact, be as small as possible in order to allow of such motion as would take place about really free joints. The breadth, A B, of the strip (see Fig. 2) is calculated so that the pressure intensity, whether due to the total thrust at the crown or to the total pressure on the joint of rupture supposed applied at the center, O, of the strip, may be equal to $\frac{1}{2} \times 120 = 60$ kilogrammes per square centimeter (=853 lb. per square inch). Calculation shows that this width is in general markedly less than one-third the full width of the joint; but, as an additional precaution, the breadth of the strips has been taken equal to one-third, which permits of confining within pretty narrow limits the zone within which the line of resistance may lie; the theory of the arch shows, in fact, that the line of resistance cuts the joint at the crown above the middle and the joint of rupture below the middle. Now, supposing there to be actual contact between the lead sheet and the neighboring voussoirs, and that the pressure at the edge of greatest pressure (the upper edge at the joints of rupture and the lower edge at the crown) reaches 120 kilogrammes per square centimeter (1,706 lb. per square inch), a limit which cannot be exceeded without the lead yielding; the breadth of the zone in which the line of resistance must lie, reckoned from the center of the joint, will be contained between the half and the third of the strip, so that it will have a width of one-sixth of that strip, or of $\frac{1}{3} \times \frac{1}{2} = \frac{1}{6}$ of the whole joint, which amounts to only 2 in. in a joint of 3 ft. If the resultant thrust approaches closer to the edge, B (see Fig. 3), a portion, A C, of the lead strip will separate from the neighboring voussoir, and the maximum pressure will exceed 120 kilogrammes per square centimeter (1,706 lb. per square inch), so that the lead will yield and the limiting pressure of 120 kilogrammes per square centimeter (1,706 lb. per square inch) will be maintained. The experience of four bridges recently built in Wurtemburg (1882-87) shows that in the most unfavorable case the displacement of the center of pressure at the crown or at the haunches is not so great as to sensibly increase the width of that zone of one-eighteenth of the joint within which the line of resistance should lie. The indeterminateness which exists at the position of the line of resistance, and as to







the stresses resulting even in the best built bridges, is thus almost entirely got rid of.

The durability of lead as used in permanent works cannot be doubted after the use made of it by the ancients and in the middle ages, in structures still standing. The Romans used sometimes to place thin sheets of lead between large blocks of ashlar. In the bridge over the River Dee, at Chester, built in 1833-34 (circular arch of 200 ft. span), and also in the bridge at Turin-on-Dora, 147·6 ft. (built in 1834), strips of lead were introduced into the joints throughout two-thirds of the arch, starting from the springings. In the bridge at Berne-on-Aar (151 ft.), built in 1844, sheets of lead were inserted in the joints of rupture. In these works the lead insured both the maintenance of the intervals at the joints and the uniform distribution of pressure upon removal of the centering.

Next we shall consider the most important question which the new method of arch construction, introduced by Mr. Leibbrand, raises, viz., how he reduces the apparently serious disadvantage of the reduction of the arch ring to one-third of its thickness at the crown and haunches, the very points which builders have hitherto been wont to strengthen, or at any rate to make of stronger materials. The voussoirs next to the lead joints bear, in fact, in this system pretty large thrusts over a part of their bed, since even in the calculation of the stability of these works, Mr. Leibbrand admits pressures of 120 kilogrammes per square centimeter (1,706 lb. per square inch)—decidedly larger than those existing in structures which exceed ordinary dimensions; *e. g.*, the piers of the bridge at Coblentz carry only 896 lb., those of the bridge at Cologne only 768 lb. per square inch. After pointing out that the voussoirs, between which the lead joints are to be placed, may be made of stone of exceptional crushing resistance (*e. g.*, basalt 39,361 lb., granite 25,582 lb., hard sandstone 23,890 lb. per square inch), Mr. Leibbrand adds that this excess of precaution is unnecessary in structures which are not exceptionally large, and that it suffices in general to use for these special voussoirs stone with a crushing resistance of from 10,660 lb. to 11,375 lb. per square inch, and this has been done in the four bridges recently built under his direction. For proving this he depends on some experiments made in 1885-86 by Mr. Durand-Claye on the crushing resistance of partially loaded stone blocks. Let A be the side of a square stone block resting on its base and carrying on its top a cast iron cube of side a (see Fig. 4). If we call f the modulus of crushing of the stone in question, $f a^2$ would be the total ultimate crushing load, if the small metal cube rested on a small stone cube of same size.

Now the load, P, which, applied to the small square area, a^2, would cause fracture of the stone, A, may be approximately expressed by the empirical formula $P = f A a$. If, then, $A = 3a$, we shall have $P = 3 f a^2$. Now if we admit the same factor of safety (s) in both cases, the safe working resistance of the stone fully loaded being $f \div s$, the total safe load W would thus be in the second case,

$$W = \frac{f}{s} \times 3a^2$$

This empirical rule is of course applicable only under the conditions of the experiments, viz., to soft stone blocks with a crushing resistance of 576 kilogrammes per square centimeter (8,190 lb. per square inch); cubes of this stone of 10 centimeters (=3·94 in.) in the side bore under the pressure of cast iron stamps the following loads:

Length of side of stamp in centimeters	10	5	3	2	1
Breaking load in kilogrammes per square centimeter	576	1047	1560	2633	4458

If, then, voussoirs of a similar stone have to bear over one-third of the length of the joint a pressure of 120 kilogrammes per square centimeter (= 1,706 lb. per sq. in.), the maximum pressure which can be transmitted to them by the lead, the factor of safety will be approximately $120 \div 1{,}560 = \frac{1}{13}$ nearly. In Mr. Leibbrand's bridges the voussoirs have been made of sandstone with a crushing resistance of 760 to 1,000 kilogrammes per square centimeter (= 10,810 lb. to 14,220 lb. per sq. in.) The factor of safety is then $120 \div 3 \times 760 = \frac{1}{19}$ nearly, if the above empirical law proposed by Mr. Flamant with some reserve (on account of the paucity of the experiments hitherto made on partially loaded stone blocks) be exact; it would at any rate be greater than the factor of safety of one-tenth hitherto adopted for the most heavily loaded parts of arches. Thus it seems clear that the new method is more rational than would appear at first sight, and it has, moreover, been applied with success in the case of four large bridges.

Having thus explained the new principle introduced by Mr. Leibbrand, some details of the bridges already made may now be given, as the practical success of the large spans attempted with only low rise is largely due to the general excellence of the design. Four large span bridges have been built in Wurtemburg on this principle; they all have the peculiarity of what may be styled "sunken abutments." These abutments are in general limited by the prolongation of the curves of the intrados and extrados below the natural surface of the ground, the curve of the intrados taking the form of a flat arch of which the visible portion is a circular arc with very low rise (usually of one-tenth span); thus they may be said to have two kinds of "span," one the effective span above ground, the other the span at foundation (see Fig. 6). These four bridges have spans and rises as below:

	River.	Near.	Span.	Rise.	Span at Foundations.
			ft.	ft.	ft.
1	Enz	Hofen	91·9	9·2	147·6
2	"	Wildbad	51·2	10·7	67·6
3	Glatt	Neuneck	55·8	9·8	68·2
4	Murr	Marbach	105·0	10·2	143·4

The visible part of the arch is alone made in ashlar, so that an extra thickness of 16 in. to 20 in. is sometimes given to the haunches, against which the visible part of the arch abuts, the curves which contain the "sunk abutments" being thus parallel to the curves of the intrados and extrados prolonged below the ground.

The abutments are generally made in Portland cement concrete, and sometimes large blocks of stone are laid in the concrete with radial bedding; this special concrete is composed of 1 volume of cement, 3 of sand, 6 of broken stone, with the addition in small spans of 30 per cent. of large blocks interspersed. The arch rings are in cement concrete in bridges of small span (*i. e.*, below 98 ft.); this concrete is composed of 1 of cement, 3 of sand, and 4 of broken stone. When it is wished to give the work a better appearance, the concrete is used only for the interior of the arch ring, the soffit of the arch being built in voussoirs of squared ashlar, and the courses of rough-hewn stone; the mortar is usually composed of 1 of cement to 1½ of sand. In large arches the soffit is built in ashlar, where the quarries are conveniently situated, or otherwise in blocks of small size, and the rest of the thickness of the arch ring is in squared ashlar; the voussoir joints prolonged to the extrados are ½ in. to ¾ in. thick, and are filled with dry mortar spread with flat trowels. The spandrel arches are of rough blocks with mortar composed of 1 of cement to 3 of sand, or of cement concrete composed of 1 of cement, 2 of sand, and 3 of gravel. The arch coverings are of cement mortar composed of 1 of cement to 1½ or 2 of sand, and are only 1·2 in. thick; but they are finished off with a layer of asphalt 0·28 in. thick, which conducts the drainage to drain pipes traversing

* Condensed from "Annales des Ponts et Chaussées for 1891," Paper 28, by Lieut.-Colonel Allan Cunningham, R. E.—*Engineering.*

the arch near the springings, or to dry stone drains placed behind the abutments.

After the above general description it will be interesting to describe one of the larger bridges in greater detail.

Bridge over the Enz, near Hofen.—The effective or visible span of this bridge is 28 meters (91·9 ft.), and its rise one-tenth thereof; the span at foundations is 45 meters (147·6 ft.) The breadth between the parapets is only 3·9 meters (12·8 ft.), whereof the roadway takes 2·5 meters and each footway takes 0·7 meter; the breadth between the arch faces is only 3·4 meters, the footways overhanging ½ meter each.

The foundations of the abutments are sunk in the sandstone, situated at 2 meters (6½ ft.) below low water, and overlaid by sand and gravel. The excavations were dressed to the natural slope of the soil down to the subterranean water level, and below this were lined with sheeting; the drainage did not exceed about one gallon per second. Portland cement of the Blanbeuren works was used for the concrete in foundations and for all the masonry. The testing of this cement was done as follows: A sample was taken from each truck and mixed into mortar with sand in the proportion of 1 to 3; it was allowed to set one day in water and six days in air; the briquettes of quick-setting cement for use in foundations were expected to bear a tensile stress of 114, those of slow-setting cement to bear 170 lb. per square inch. The "sunk abutments" resting on the concrete of the foundation are in rough blocks, with joints perpendicular to the intrados. The soffit rests on a mass of dry stone covered with a layer of mortar forming a centering to it; this mortar, composed of 1 cement to 3 of sand, was used in one-fifth of the masonry.

The centering rested partly on piles driven firm, partly on posts not driven. The sand boxes had a base of 3·9 square inches and a depth of sand of 4¾ in.; pieces of sheet tin prevented the sand (which had been washed and dried) from being wetted by rain. The centering was loaded with the whole of the voussoirs before the masonry work was begun; this was done symmetrically and took two days; the movements of the frames were insignificant, they varied from one-twenty-fifth inch to one-tenth inch, thus showing that the centering was very stiff. The whole arch was built of excellent sandstone found at 1¼ miles' distance, with a crushing resistance of 13,240 lb. per square inch, according to the tests at Stuttgard.

Strips of soft laminated lead of 19⅜ in. wide and ¾ in. thickness were placed at the center of the joints at the haunches, covering the central third thereof; their length was 41½ in., and they were spaced 3·94 in. apart. Each of these sheets rests at its lower edge on three points fixed in holes run with lead and projecting ⅛ in. from the bed joint. These sheets were applied to the haunch joints by gentle blows from a wooden mallet; the next voussoir was then laid on the sheet, and the void of the joint was then filled with tow and a thin layer of cement. At the crown a sheet of lead 13¾ in. wide and ⅛ in. thick was laid at the center of the joint in three pieces. The arch ring was set with joints of ⅛ in., the width of which was insured by wooden wedges of 2 in. by ⅛ in. After having laid a row of voussoirs, the joints were washed, they were then calked with tow for a depth of 1·18 in. at the intrados and face, and were afterward rammed with cement mortar (composed of 1 cement to 1½ sand) with flat iron trowels; the five joints next to the crown were set all together. Eight masons and eight laborers, working in two shifts, laid the whole arching in 7¼ days' work. During the laying the five voussoirs next the haunches, it was noticed that the lead joints shrank a little at the intrados and gave a little at the extrados.

Observed Widths of the Semi-Free Joint at the Crown (in millimeters).

Time of Observation.	Upstream.		Downstream.	
	Extrados.	Intrados.	Extrados.	Intrados.
After keying	21·0	23·0	17·9	24·0
After emptying No. 1	20·0	21·0	16·0	24·0
After emptying No. 2	20·0	21·5	15·5	24·0
After emptying No. 3	19·0	22·3	14·3	24·8
After striking the centering	18·6	22·3	14·3	24·7

Observed Widths of the Semi-Free Joints at the Haunches (in millimeters).

Time of Observation.	Left Bank.				Right Bank.			
	Upstream.		Downstream.		Upstream.		Downstream.	
	Extrados.	Intrados.	Extrados.	Intrados.	Extrados.	Intrados.	Extrados.	Intrados.
After keying	29·0	12·0	26·0	18·5	33·0	14·0	32·0	18·0
After emptying No. 1	30·0	11·5	26·0	17·0	33·0	12·5	32·0	17·0
After emptying No. 2	30·0	11·0	26·5	16·0	33·0	12·0	32·0	16·5
After emptying No. 3	30·5	10·5	26·5	15·5	33·6	11·5	32·4	15·9
After striking the centering	30·3	10·5	26·3	13·4	33·4	11·1	32·2	15·7

Fifteen days after keying, the emptying of the sand boxes was started, but the centering was lowered only ⅛ in. The sinking of the arch at the crown, after six such emptyings, was only ¾ in. upstream and ⅝ in. downstream. Three more emptyings were done twenty-eight days after the arch was finished; the sinking at the crown was then 1¼ in. upstream and 1 in. downstream. Lastly, thirty-five days after keying the sand boxes were entirely emptied out in four operations, after which the total sinking was 1⅜ in. upstream and 1½ in. downstream. In the four weeks following all the masonry of the work was finished, and a total sinking of 2¼ in. upstream and 2⅛ in. downstream was noticed. Observations afterward made have not shown any further sinking.

It is particularly interesting to study the observations made as to the opening of the lead joints during the lowering of the centers. (See tables annexed.)

The lead sheet at the crown remained in complete contact with the contiguous voussoirs throughout its breadth. The table above shows that after the keying the thickness varied at the intrados by ± 1/10 millimeter (= 1/254 in.), and decreased by 1/10 millimeter (= 1/254 in.) at the extrados; thus the pressure is not uniformly distributed. The line of resistance cuts the joint above its center, and in a zone equal at most to one-sixth of the width of the lead sheet—*i. e.*, at most 2¼ in.—from the center. The pressure at the most heavily loaded edge of the lead sheet does not exceed 120 kilogrammes per square centimeter (1,706 lb. per square inch), and the voussoirs next the crown are worked in the most unfavorable case up to only 28·2 kilogrammes per square centimeter (427 lb. per square inch), as may be seen by the graphic construction in Fig. 13.

The lead sheets at the haunches behaved otherwise, expanding at the extrados and contracting at the intrados as shown in the table; they became free at their upper edges, so as to be in contact only over 13¾ in. The pressure over this width is represented by a triangle, and the point where the line of resistance cuts the joint is situated in the most unfavorable case at 5¼ in. above the center of the sheet. The maximum pressure on the most heavily loaded edge reaches in this case 130 kilogrammes per square centimeter (= 1850 lb. per square inch), and yet the lead does not yield. The voussoirs next the haunches are worked in the most unfavorable case to 23 kilogrammes per square centimeter (327 lb. per square inch). Now it has been shown above that these exceptional pressures of 1,700 to 1,850 lb. per square inch, borne at certain points of the neighboring voussoirs, are not dangerous. Moreover, no crack has yet been seen in the masonry.

Experiments were also made on the movements at the crown during the passage of rolling loads of about 5·4, 6, 7·5, 8, and 11 tons; these are shown in table below:

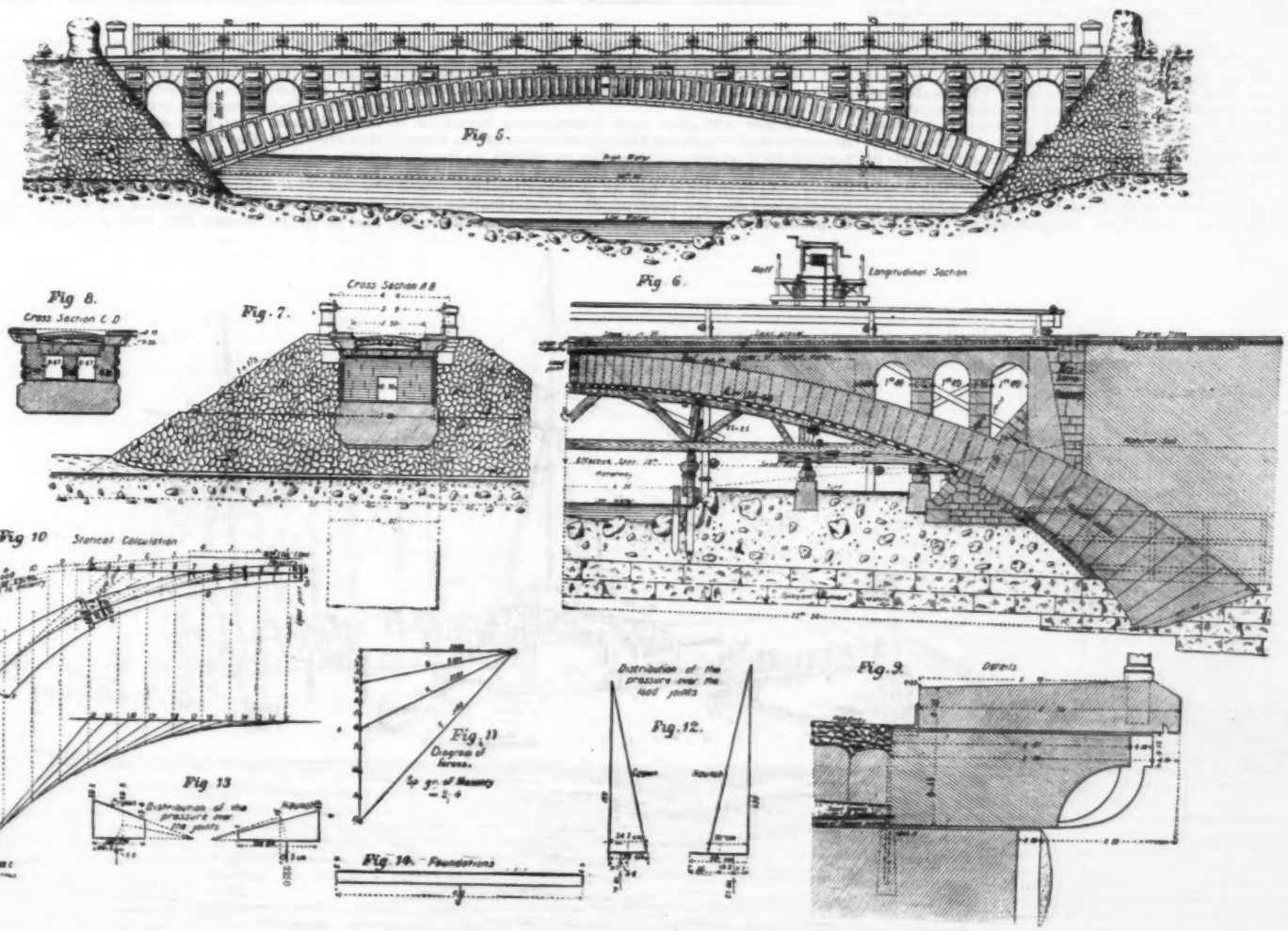
Sinking at Crown (in millimeters).

Nature of Load.	Weight in Tons.	Sinking at Crown (in Millimeters).			
		During Passage of Load.		Unloaded.	
		Upstream.	Downstream.	Upstream.	Downstream.
Empty roller	5·4	0·20	0·30	0·15	0·15
Short timber cart	6·0	0·25	0·20		
Long " "	8·5	0·30	0·40		
Transport wagon	7·5	0·25	0·30		
Timber "	8·0	0·30	0·40		
Full roller	11·0	0·50	0·55	0·35	0·35
" " ascending	11·0	0·45	0·40		
" " descending	11·0	0·60	0·70		
" " ascending	11·0	0·55	0·60		
" " descending	11·0	0·65	0·80		
" " ascending	11·0	0·45	0·50		

After the passage of the loads, the crown always recovered its normal position.

After the completion of the work the lead joints were cleaned and grouted with cement mortar. The time occupied in execution of the whole work was ten months.

The total cost, foundations and pumping included, was 1,224*l.*; the cost per square foot of plan (12·8



BRIDGE OVER THE RIVER ENZ, NEAR HOFEN, WITH SEMI-FREE JOINTS.

ft. between parapets by 91·9 ft. effective span) is about 21s.

Summary.—We may now sum up the results of the experience gained in the construction of the above and other bridges by Mr. Leibbrand. The object of forming three of the joints (at the crown and haunches) of thin lead sheet of a width of only one-third the thickness of the arching is to insure that the line of resistance shall be confined within narrow limits at those joints, thereby approximately fixing its position throughout, and thence rendering the approximate calculation of the thrust of the arch a matter of certainty instead of a mere vague guess (as heretofore).

In consequence of this uncertainty, the thickness of the arching has hitherto been computed by empirical formulæ from the span and rise only, taking no account of the load carried nor of the strength of the material of the arch ring; but with the removal of this uncertainty, it will now be possible to compute the thickness of the arch ring in a rational manner. To carry out this object, the lead should be in such thin strips as to be worked up to its yielding point; for spans of less than 130 ft., soft laminated lead yielding at 1,700 lb. per square inch should be used, and for larger spans hard lead yielding at 4,270 lb. per square inch should be used. In large spans, stone of great strength, *e. g.*, basalt, granite, etc., should be used in the voussoirs next the leaded joints. To secure the advantages fully, it is further necessary that the lead strips should be in actual contact with the voussoirs before and until the keying of the arch: this may be managed by not setting the joints near the lead joints in mortar until shortly before keying; they may be temporarily filled with sand, or may be set in mortar at first only near their centers, and finished in mortar shortly before keying.

It is not necessary that the voids in the leaded joints should be filled up with mortar; if filled at all, the filling should be done after all the masonry is done. In all Mr. Leibbrand's bridges the striking of the centerings was begun as soon as the mortar was well set; but the lowering was very gradual, by steps of about $\frac{1}{10}$ in. at a time, spread over several weeks.

H. M. FIRST-CLASS CRUISER GIBRALTAR.

RECENTLY there was launched from Messrs. Napier's yard at Govan the first-class cruiser Gibraltar. We give an illustration of the ship as she would appear in Belfast Harbor. That situation has been selected because a previous Gibraltar, one of the old line-of-battle ships, lies there, and has been introduced into our picture for the sake of comparison.

The new Gibraltar is a steel twin-screw cruiser of 7,700 tons displacement and 12,000 indicated horse power, with triple-expansion engines by Messrs. Napier, the builders of the hull. She is 300 ft. in length and 60 ft. in breadth, and she will, when ready for sea, draw rather over 24 ft. of water. There are six boilers with forty-eight furnaces. The cylinders are 45 in., 59 in., and 88 in. in diameter, respectively, with a 51 in. stroke. It is calculated that developing 5,500 horse power the ship will have a speed of 16 knots; developing 10,000 horse power, a speed of 18½ knots; and developing 12,000 horse power, with forced draught, a speed of 19½ knots. The coal capacity is 850 tons, and the radius of action at economical speed is 10,000 miles. The armament will consist of one 9·2-in. 22-ton gun; two 6-in. 5½-ton quick-firing guns; ten 6-in. 5½-ton quick-firing guns, mounted five on each broadside, six being on the upper, and four, in sponsons, on the main deck; twelve 6-pounder quick-firing; three 3-pounder quick-firing; eight machine guns; two field or boat guns; and four 14-in. torpedo ejectors. The protective deck has a maximum thickness of 5 in., and a minimum thickness of 2 in., and is of steel. Above and below the slopes of it there are coal bunkers. As the engines rise somewhat above the steel deck, the upper parts of them are protected by 5 in. inclined plates backed with teak. The conning tower is of 12 in. plates; the larger guns are protected by steel shields, and, in addition to very numerous watertight compartments, there is a double bottom amidships. The total estimated cost of the vessel is just over £340,000, of which about £188,000 is for hull, masts and rigging, and £100,000 for machinery. The Gibraltar will have two funnels and two light masts, and will, like the others of her class, be fitted as a flagship. The launch was quite satisfactory.

The present Gibraltar is the eighth of the name; the seventh—shown to the left in our engraving—is known as the Grampian. She is a wooden screw ship, built at Devonport in 1860, and is used as a training ship for boys at Belfast. She was finished just about the time when wooden walls gave place to ironclads.—*The Engineer.*

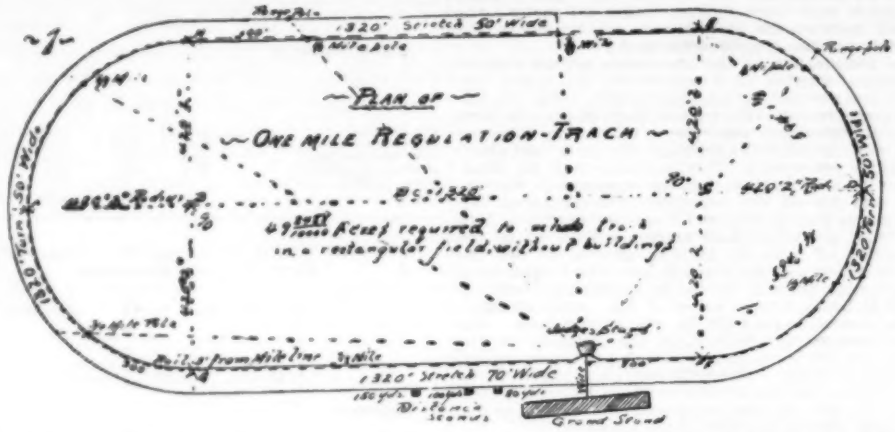
THE CONSTRUCTION OF RACE COURSES.

F. B. KRAUSE, C.E.

AT this time of the year, when the balmy days of spring are thawing out, so to speak, all horsemen who have secluded during the winter, and inspiring all to activity in making preparations for the season, and new race tracks are being built, or about to be built, and old ones repaired, an article on the construction and maintenance of race tracks, it is presumed, will be of interest.

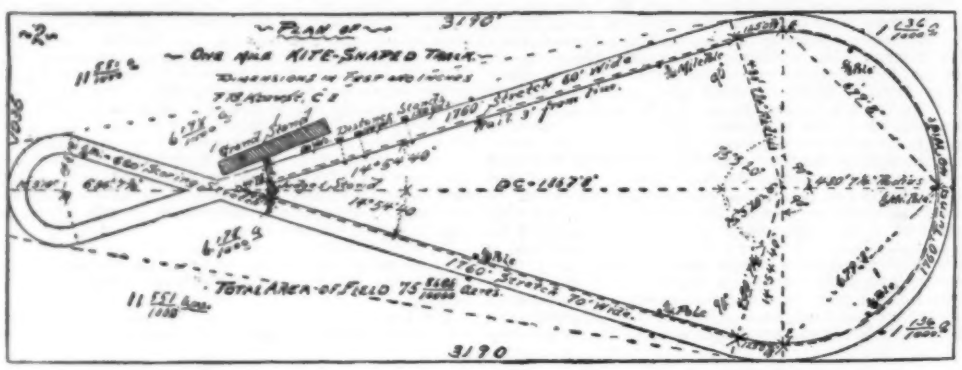
The writer will give such information herein as is necessary and useful for the construction of the fastest possible race course, of the shapes shown in the diagrams, and for maintaining the track in the best condition. As each track has its peculiarities due to soil, location and climate, these conditions and features must be practically studied in constructing and maintaining the track, and treated according to the best judgment of the person in charge of the track, to secure the best results. The proper method to pursue in constructing the race track will be as follows:

I will assume that the shape and size of the track to be constructed has been decided upon, but that a site has not as yet been selected. If there are several available sites, it will be advisable to have surveys of

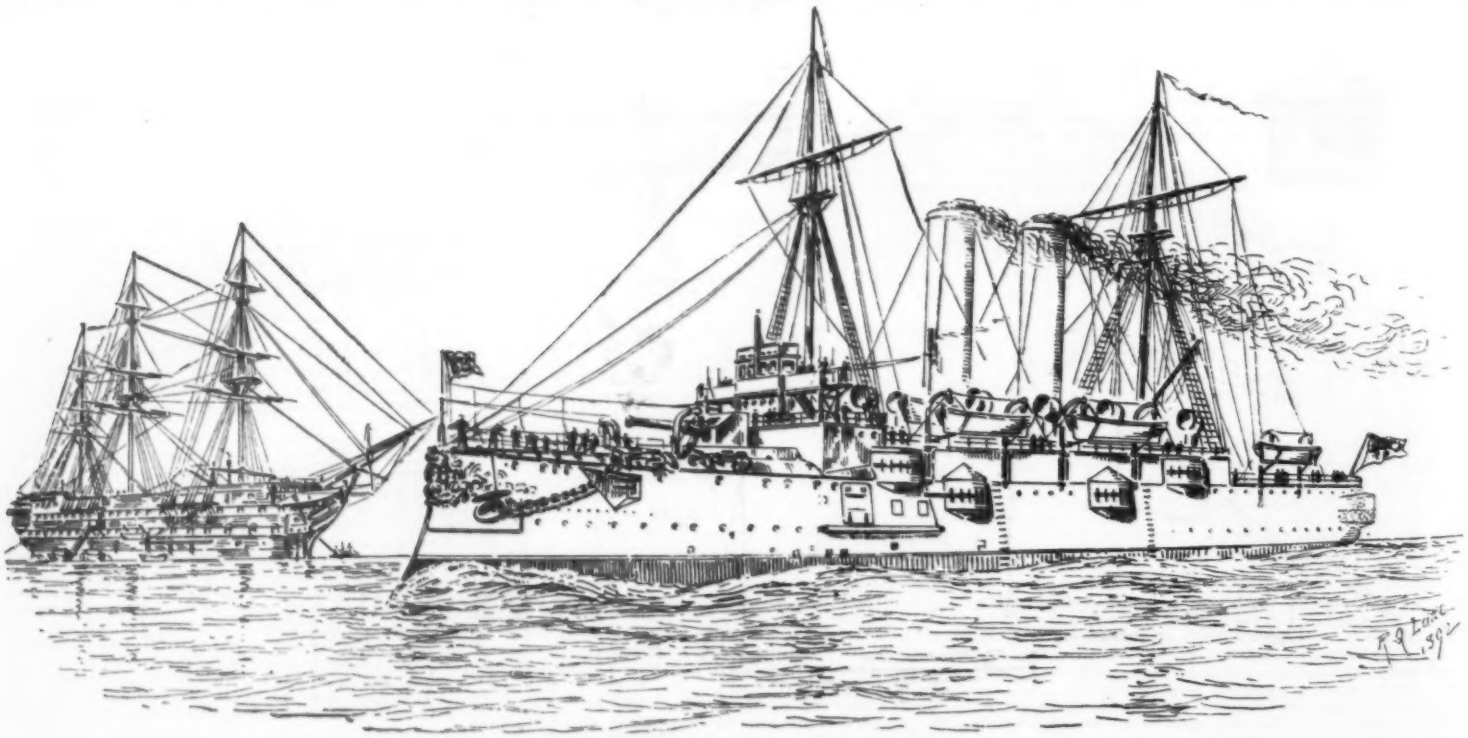


each one made by a competent civil engineer, who will make maps, profiles and estimates of the cost of construction of the track on each site. By reference to them an accurate choice of the most suitable one can be made, and other knowledge gained for future use.

Having chosen the site, the track will be accurately laid out. By reference to the diagrams the requisite dimensions of the several tracks will be found, with other useful figures. Diagram No. 1 represents the mile regulation track, No. 2 the mile kite-shaped track, and No. 3 the half mile regulation track; No. 4 is a plan of a half mile kite-shaped track. To lay out the



regulation track, the center line, as shown on the diagrams, should be staked out, setting stakes at the points, A, B, C and D; stakes should then be set at right angles to the center line at the points, E, F, G and H. The turns and stretches will then be staked out. Stakes should be set 50 or 100 feet apart on the stretches; on the turns for a mile track regulation shape, stakes may be set 30 ft. apart, or less if desired; for the turns of a half mile track regulation stakes may be set 15 ft. apart or less. In staking out the kite-shaped track, stakes should be set at the points, B, D, C and G, in the center line and at right angles to the



THE BRITISH FIRST-CLASS CRUISER GIBRALTAR.

center line at E and F, also at the commencement of the stretches, one hundred and twenty-five feet and seven-eighths of an inch from the points, E and F, for the mile kite-shaped track, and sixty-one feet five and one-quarter inches from the points, E and F, for the half mile kite-shaped track. Stakes may be set forty feet apart or less on the turns of a mile kite-shaped track and twenty feet apart or less on the turns of the half mile. The stakes for the stretches of the kite-shaped track may be set the same distances apart as on the stretches of the regulation tracks. The engineer will use the most convenient method for laying out the curves for the turns.

The diagrams of the tracks, as given in this article, show the turns laid out in the usual manner with circular curves, but I advocate transition or spiral curves as being a very desirable improvement on them. It is well known by drivers that as tracks are usually, in fact I may say always have been, laid out (with but one exception, and that within the present year), the turns, beginning abruptly as they do with circular curves, are an obstacle in the way of speed making. With circular curves it is necessary to begin the sloping of the turns some distance on the stretches and not attain the proper rise until the same distance on the turns; this inconsistency is done away with entirely by spiral curve.

The diagram number 9 shows a comparison of the circular and spiral turns. The spiral turn is represented by the full lines and the circular by the dotted lines. Beginning at D, the spiral turn gradually increases in sharpness until the sharpest point of the turn is reached at F, then the turn gradually eases off until it vanishes at the point, E. This allows of sloping the turns gradually from the stretch, increasing until the greatest slope is reached at F, then diminishing gradually to the stretch as the turn becomes easier. At every point the slope of the turns may be just sufficient to counteract the centrifugal force. The transition from stretch to turn and back to the stretch again will be perfectly easy, and all abruptness and consequent danger avoided. The principal gain will be in the speed of the track, which will be, with properly laid out spiral turns, nearly two-thirds of a second. It is needless to say that two-thirds of a second is worth saving or gaining in speed. Horsemen can appreciate the value of such a gain when it gets down below 2:10.

Accurate levels and cross sections of the track should be taken by the engineer and the most easy and economical grades chosen, care being taken, if the soil is suitable for the formation of the roadbed without top-dressing, to conform as nearly as possible to the natural surface of the ground. If the track is to be built on contract, accurate estimates and explicit specifications should be drawn up and inserted in the contract. Having chosen the best grade for the track, stakes should be set to grade beside the stakes that were set in laying out the track. If the cut or fill is too great in places for setting stakes to grade, stakes should be set with the cut or fill marked on them. The stakes should be numbered to designate them. In numbering the stakes it will be convenient to begin at the point, F, for the regulation track, and number the stakes according to their distance from that point. Each one hundred feet should be called a station, and the amount over an even hundred feet, plus; thus if a stake were three hundred and fifty feet from the starting point, it would be numbered three plus fifty (3 + 50).

Diagram number 8 shows a plan for a mile kite-shaped track without the stretches crossing, which does away with the danger of collisions, at the crossings of the stretches, that exists on the kite-shaped tracks built as shown by diagrams Nos. 2 and 4. The objection to this form of track, on account of the turn immediately after the finish, is not as great as it appears at first thought, for the turn is nearly as easy as that of the regulation track. This form of track does not cut the field up as badly as the other, though it occupies as great an area.

When grading the track, where there are fills, as much teaming as possible should be done over the material deposited, so as to pack it in place thoroughly. The nearest fills should be made first. The best condition of the ground for grading is when it is neither too dry nor too wet, but in a moist state, and the best time for grading a track will usually be in the fall of the year, so that it will be thoroughly settled by spring. If the track is to be top-dressed, allowance should be made in the grading, the fills being made to within six or eight inches below the height of the desired grade.

For draining the track a ditch should be dug around the inside of the course six or eight feet from the rail.

The stretches should be sloped about one-eighth of an inch to the foot toward the inner edge of the track, so as to allow the water to flow off readily after a heavy rain.

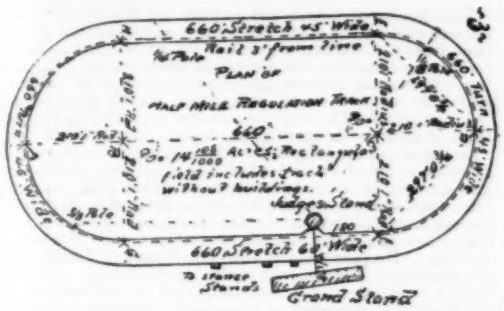
When the grading has been completed, the surface of the track should be harrowed thoroughly to break up the lumps, then thoroughly rolled and sprinkled to bring it to a compact state. A scantling surface dresser, such as is shown in the diagram, Fig. 5, will be found very convenient to keep the roadbed free from waves and to remove pebbles and other such small obstructions. To make the surfacer, get ten 2 × 4 scantlings sixteen feet long and two twelve feet long. Bore holes in the sixteen foot scantlings five-eighths of an inch in diameter and three feet six inches apart from center to center of the holes. The bottom layer of scantlings will be set on edge and the top layer flat, as shown in the diagram. Bolt the scantlings together with half inch bolts, placing washers between the scantlings and between the bolt heads and the scantlings. The two pieces of scantling twelve feet long should be used to make the bars, P, P. They should be bolted on at C, C, so that they will be movable, and should have holes bored in them at H, H, about as many as shown on the diagram. Two bolts should be set in the middle scantling at B, B, so as to be inserted in any of the holes in the bars. A place to hitch, at A, should be made. The surfacer may be put together square, but may be set at any angle, such as is shown in the diagram. As different conditions of the soil require different angles of the surfacer in order to carry off the pebbles, and as a sharp angle will especially be required on the turns, this form of surfacer will be very convenient, although it may be made permanently square with less expense and work, and should then be hitched to at one side of the center. A first-class road scraper or roller and one or two harrows will be necessary implements to have for the proper maintenance of the roadway; also a sprinkling wagon with tires six or eight inches wide. Some tracks will require wider tires than others, on account of the nature of the soil.

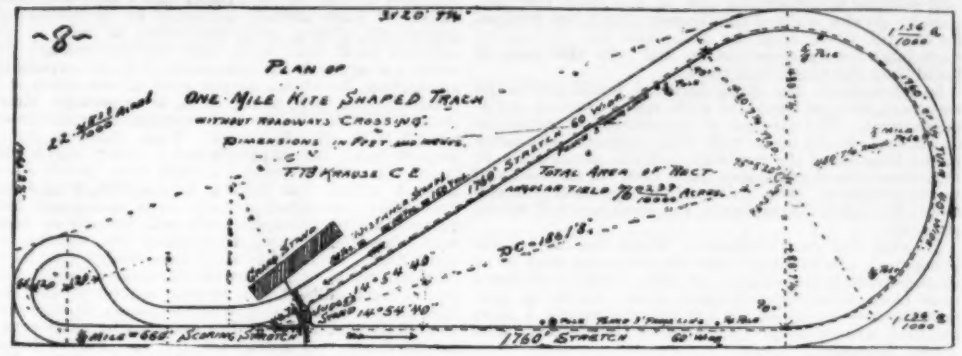
Much care will be required to maintain the track in the best condition for speed. The use of the road scraper will be required occasionally, but mostly after heavy rains, in dressing up the turns. Before dressing the track, if it is not moist, sprinkle it well, then the dressing may begin by harrowing lightly; smooth out all waves and roughness with the surfacer, and roll well to a compact and firm surface. It must be remembered that the smoothest track surface presents the least resistance to motion of both horse and vehicle, and that a slight roughness of the track will materially increase the resistance of the vehicle. The fastest track will therefore have a surface as perfectly smooth, uniform and free from grades as possible; the roadbed will be firm and slightly elastic. A clay loam or clay soil, well kept, makes the best natural surface for the track.

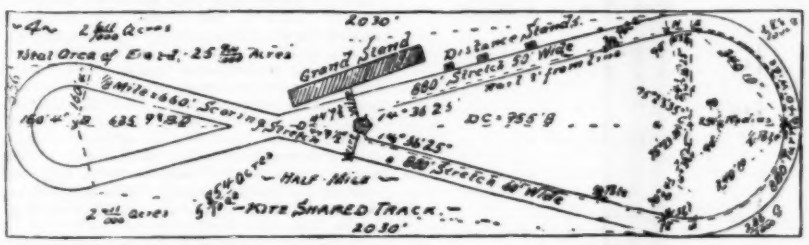
The sloping of the turns is a point which should be particularly observed to secure a fast track; but for a training track they should not be sloped too much. For a fast regulation mile track the turns should be sloped one and one-half inches per foot; for a fast half mile track, two and one-quarter inches per foot; for a fast kite-shaped track the turns should be sloped one and three-eighths inches per foot, and for a half mile track, two inches. For a training track, one inch per foot will be sufficient slope for a mile, and one and one-half for a half-mile track. The slope of the turns should begin about a hundred feet from the commencement of the turns on the stretches, and attain one-half of the full slope by the time the turns are reached, and increase to the full slope the same distance on the turns. Particular attention should be given to keeping the turns in perfect order and to preserve as perfectly uniform and as waveless a surface as possible.

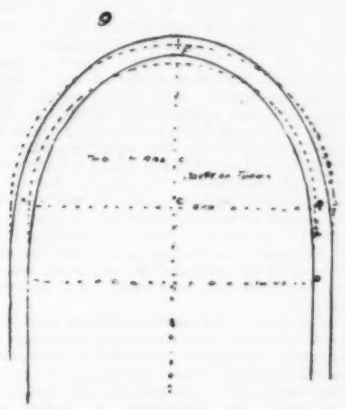
Grades should be avoided as much as possible, especially on the turns. If there are any grades, it will be best to have them in the first half of the mile or half mile, and as far as possible to have the down grades on turns and home stretch. Very light grades, two or three inches in the hundred feet, will not affect the speed of the track materially. The effect of grades may be appreciated, when one considers that, say with a grade of six inches per one hundred feet and a speed of 2:10, the weight of the horse, driver and sulky combined being 1,200 pounds, the horse has to perform work equivalent to lifting 240 pounds one foot high per second on account of the grade.

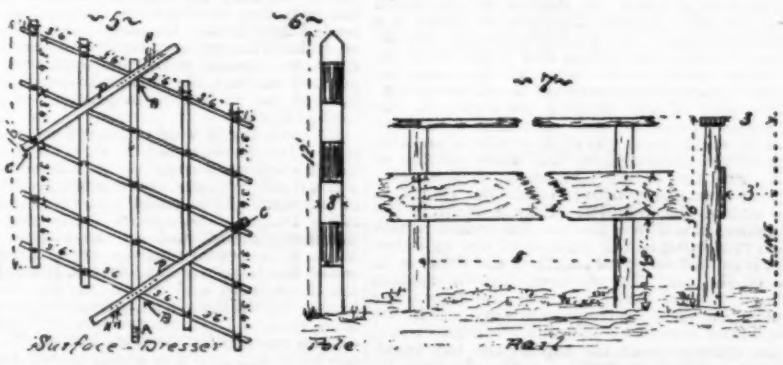
The rail should be set as regulation now requires, three feet from the line of the mile or half mile course. Four feet would probably be nearer the correct location, so that a horse would travel no more than a mile in making the circuit, but the regulations do not admit of setting the rail further from the line than three feet. The style of rail is shown in the diagram No. 7; the poles should be from ten to twelve feet in height and about eight inches in diameter. It will be well to paint them red and white in alternate bands and to varnish them, to have poles that will be plainly visible at a distance. The poles should be set in range from the judges' stand to the point in the line of the course where the quarter, half or three-quarters mile distance comes. Poles should be set in range on both sides of the track. Eighth-mile poles will be convenient. The judges' stand should set back from the track about twelve feet, and for a regulation mile track, 300 feet from the turn; for a regulation half mile track, about 180 feet from the turn. The diagram shows location of the judges' stand for kite-shaped tracks. The wire should extend across the track at right angles. There should be two wires, one being perpendicularly above the other about three feet. There should be distance stands located as shown on the diagrams. The grandstand should be set back from the track twenty feet, and the pitch of the seats should be about two feet in three. To secure the best view, the grandstand should be set at an angle with the track of about ten feet in a hundred. The other buildings should be within convenient distance of the judges' stand and track. The grandstand and other buildings will of course be built to suit the convenience and tastes of the parties for whom they are to be constructed, and they will be the judges as to the extent of the buildings necessary to be











erected for the purposes for which the track is to be used.

The areas of the fields required for the various tracks are given in the diagrams; and with the exception of the kite-shaped tracks, include only enough land for the tracks. The amount of land required, outside of that necessary to contain the tracks, will have to be decided by the persons building the track.

Although a kite-shaped track is from two to three seconds faster than a regulation track, it has its unfavorable points. The principal disadvantages are that it is not adaptable for distances greater than a mile, half mile, or whatever the size of the track may be; that as good a view of the horses cannot be obtained for the full distance of the heat; and that it requires more land for its construction and will cost more to build than the regulation track.

In reference to the spiral curves, I would advise the reconstruction of the turns with spiral instead of circular turns. The expense of reconstruction would be small, and would make very little apparent alteration in the location of the roadway, and the advantages to be gained would pay many times over for the cost and work necessary. The value of the increase in speed would be difficult to estimate, but certainly well worth gaining.

Leaving the rest to those in whom the care of the track rests, and trusting that the foregoing may be of some benefit, however great or little, for limit of time I must close, believing that such minor details as present themselves, which in the present article I have omitted, will be properly solved by them.—*American Horse Monthly.*

THE TECHNOLOGY OF THE PAPER TRADE.

ALMOST as important as the introduction of machinery has been the application of chemicals in the manufacture of paper. We have already seen what important parts soda and chlorine and alumina play in the various stages of the process, and now it falls to us to consider the nature of the commercial chemicals containing these active agents. First in point of time, if not also in importance, we have caustic soda. This agent, as now used, was unknown as a commercial article until little more than a quarter of a century ago. It is now manufactured in very large quantities, and is used extensively in soapmaking, bleaching, papermaking, and—in smaller proportion—in many other trades. We shall first look at the chemical structure of this substance, and of the salts formed by its union with carbonic acid, which are also useful to the papermaker. Then we shall glance in succession at the commercial methods of producing these agents; at their employment in the paper mill; the methods of testing or valuing them; and the methods of recovering them after they have done their work, and of reusing them in the mill.

Caustic soda consists essentially of the metal sodium combined with oxygen and hydrogen. When sodium is burned in oxygen gas, two equivalents of the metal combine with one of the gas, and sodium oxide (Na_2O) is the result. This substance has a powerful affinity for water, with which it combines, forming sodium hydrate (NaHO). The reaction may be symbolized thus: $Na_2O+H_2O=2NaHO$. This agent, contaminated with varying proportions of soda and other salts, is known in the arts as "caustic," or caustic soda. As its name implies, it is highly caustic or burning in its nature. It is so very deliquescent that, if left exposed in the air for some little time, it will become liquefied by the water it absorbs.

For all substances of an acid nature caustic soda has a strong affinity, and it is in virtue of this property that it is so eminently serviceable in the treatment of raw fiber yielding vegetable substances. When exposed to the air, it not only absorbs moisture, as already stated, but also carbonic acid, carbonate of soda being the result. The exact composition of this substance in the anhydrous condition is Na_2CO_3. When this is formed from sodium hydrate, a molecule of water is involved in the reaction, thus: $2NaHO+CO_2=Na_2CO_3+H_2O$. Soda ash and soda crystals consist essentially of carbonate of soda, the former being anhydrous, and the latter combined with seven equivalents of water of crystallization. The soda recovered by incineration from the waste soda leys is also a carbonate, indeed, a crude soda ash often quite as rich in available soda as ordinary commercial ash. The impurities are, however, generally of a more objectionable nature.

Common salt is the native sodium compound upon which the chemical manufacturer operates, to produce the numerous soda salts met with in commerce. Upon this he brings oil of vitriol, or sulphuric acid, to bear, with the result that it is split up into two, the chlorine going off with the hydrogen as hydrochloric acid, which is in turn also split that the chlorine may be got to make bleaching powder. The sodium takes the place of the hydrogen which has been eliminated from the sulphuric acid, and thus becomes the basis of a new chemical structure known as sulphate of soda, or salt cake. This substance is of no value to the papermaker, but it is the first step toward producing what is really wanted.

The salt cake is mixed with limestone or carbon, or small coal, and heated to fusion in a reverberatory furnace, the practical result being the production of soluble soda—partly caustic, partly carbonated—and insoluble sulphides of calcium. Lixiviation dissolves out the valuable soda products, leaving the insoluble calcium and sulphur compounds to be disposed of as best the manufacturer can, so as to minimize the nuisance which must necessarily result from their gradual decomposition, and the formation of soluble sulphides.

The soda solution may either be evaporated, and the product furnaced into soda ash, or it may be treated with caustic lime, and the resulting caustic liquor concentrated and finally kept in a state of fusion at a red heat until the impurities are so reduced in quantity that the product may test 60 or 70 per cent. of real soda (sodium oxide), as may be required. What is known as caustic soda ash contains variable proportions of its soda in the caustic state, the bulk of it, however, being carbonated. Ordinary ash contains but little caustic, and the difference is produced by employing different methods of evaporating the crude liquor, and calcinating the product. Refined soda ash is just ordinary soda ash freed from color and certain impurities by resolution, clarification and evaporation, or by the treating of the finest of the crude liquors with small proportions of nitrate of soda, to oxidize the sulphides. It is not necessarily, or, indeed, usually, stronger than ordinary ash. Freedom from color, sulphur, and mechanical impurities are its characteristics. When a hot saturated solution of refined soda ash is allowed to cool, nearly pure carbonate of soda crystallizes out, in combination with seven equivalents of water—the crystallized product being what is so well known as soda crystals.

The important part which caustic soda plays in the economy of the modern paper mill is now well understood. I have already adverted to its action upon grease, oils, gluten, resin, and silica, as well as upon cellulose itself, and need only further remark that, while the agent is indispensable, it is also expensive—amounting to about 10 per cent. of the value of the product—and this being so, it is important that it should be used in the most economical manner consistent with effective work. That there is in this respect room for improvement in very many mills, there can be no doubt. I have seen much accomplished where the boiling arrangements had been previously considered perfect. It is sometimes found economical to purchase soda ash instead of caustic soda, dissolving it, and causticizing the solution with quicklime. When the waste lime sludge can be readily got rid of, it is possible to make a profit of this, but at most mills it is a serious matter to get rid of the sludge, as well as the other refuse matters which so rapidly accumulate. For size making, soda crystals are no doubt very suitable, being the purest form in which soda can be purchased commercially. From experiments made under my own direction, however, I am convinced that an equally good size can be made with soda ash, provided only it be quite free from color and mechanical impurities, and it should not be difficult to secure a supply meeting these conditions. The result of the use of ash as against crystals is a saving in the sizing charges.—*Paper Trade Review.*

DETECTING WATER IN PETROLEUM TANKS.

AN instrument for ascertaining and recording the amount of water lying beneath petroleum in a ship's

hold or a storage tank has just been brought out. This instrument is the joint patent of Messrs. Boverton and Robert Redwood and H. Barringer.

The object of the instrument is to overcome the disadvantages which attended the practical use of the instruments hitherto employed for this purpose. The action of the instrument depends upon the change produced by the water upon a strip of paper prepared by chemical means so as to be unacted upon by oil, while the same is speedily and permanently altered by the action of water.

The instrument is very simple, as will be seen by the accompanying illustration. It consists of a hollow weighted brass cylinder, somewhat larger at its upper extremity than at its lower. A shallow groove is cut on both sides of this cylinder, alongside of which is a scale divided into inches and tenths of an inch. On the cylinder there is also a brass ring, which slides over the cylinder, fitting tightly on the top, and thus securing the prepared paper in the groove cut for its reception. The bottom part of the cylinder, as shown in the sketch, is supposed to have been sunk into a tank at the bottom of which there was eight-tenths of an inch of water, which is registered by the white portion of the paper. The use of the instrument is simplicity itself, all that is necessary being to slide the ring A to the lower end of the cylinder. Take a strip of the prepared paper, pass it over the pin, the ends of which will be seen projecting at the bottom of the cylinder, and adjust it so that an equal length of the paper is on each side of the pin, the prepared (brown) surface being turned toward the pin. Pass the paper, one side at a time, between the ring and the cylinder at the point where the groove or channel commences, and holding the cylinder near the top in the left hand, retain the paper tightly in position in the channels by the finger and thumb. Then slide the ring to the top of the cylinder, and the paper will be found firmly fixed on each side with, of course, the prepared surface outward.

Having thus prepared the instrument for use, it is to be attached to a cord of suitable length and lowered into the tank the presence and depth of water in which is to be determined. When the instrument is nearing the bottom of the tank it should be lowered slowly and cautiously so that it may be retained in a vertical position. On touching the bottom it should rest undisturbed for such time as may be necessary to effect the requisite alteration of the chemically-prepared surface (about 30 seconds is usually sufficient), and on then being drawn up, the depth of the water will be indicated on both sides of the instrument, thus giving a duplicate record, and showing in the majority of cases whether the instrument has retained its vertical position. The instrument is being made by Messrs. Fraser & Co., of London.—*Chemical Trade Journal.*

ELECTRIC METERS, MOTORS, AND MONEY MATTERS.*

By Prof. W. E. AYRTON, F.R.S.

THE professor began his lecture by illustrating the dependence of the electrical energy obtained in a given time from an electric current, both on the strength of the current and on the electrical pressure, by comparing the current to a supply through a pipe of colored water, to be paid for in proportion to the amount of color supplied. The amount of color supplied in a given time would be proportional to the product of the amount of liquid supplied in that time by the quantity of color in every cubic foot of the solution. Similarly the amount of electrical energy supplied from an electric main in a given time would be proportional to the strength of the current by the electrical pressure, and therefore the costs should be measured in the same manner. He pointed out that the Board of Trade unit of electrical energy, the price of which in London varied from 7d. to 8d., was obtained by multiplying a coulomb (the quantity of electricity carried across any section of a conductor in a second by a current of an ampere) into a volt, the unit of electrical pressure, and then multiplying the result by the number of seconds in 1,000 hours. The professor observed that instruments for measuring electric current, electric pressure, and electric energy were known as ammeters, voltmeters, and wattmeters respectively, the watt being the name given to the unit of electrical energy. The meters employed by the electric supply companies simply measured the number of coulombs passed through them, and should therefore be called coulomb meters. The name was not employed by these companies, who usually called these instruments electric supply meters, possibly because thay had no desire to call attention to the fact that what was registered by the meter and what was charged to the consumer were two entirely different things. The quantity measured was the number of coulombs passed through the meter, while the quantity charged for was the product of this by the number of volts at which the electricity was supplied.

Two groups of lamps inclosed in glass-fronted cases, showing as models of electrically-lighted houses, were then exhibited, with the same current passing through each of them, but the pressure in one many times greater than in the other. In the former case the model house was brilliantly illuminated, while only a feeble light was obtained in the second case. This was owing to the electrical energy consumed in the one at higher pressure being many times greater than the amount consumed in the other, though in a given time a coulomb meter would give the same indication for each. Thus in order to convert the readings of a coulomb meter into Board of Trade units, it was necessary to assume that the pressure kept up in the electric mains from a supply station remains everywhere and at all times constant. It was physically impossible to do this, and, therefore, the Board of Trade allowed a variation of pressure within the limits of 4 per cent. above and 4 per cent. below the nominal pressure, or an extreme variation of 8 per cent. The effects on the light of such a variation of 8 per cent. in the electrical pressure was shown by means of the model houses.

The professor stated that a series of experiments had been made by himself and his students on the variation in light caused by a variation of 8 per cent. in the pressure. The experiments were confined to Edison-Swan lamps, as these were the only ones which could be used in this country while the existing patent was in force. They found that with these lamps the variation in the amount of light given was about seven times as great as the variation in the pressure; so that under the Board of Trade regulations a 16 candle lamp might vary from 12 to 20 c. p. Even larger fluctuations than this were often allowed to take place unnoticed by the consumer. It was easy to understand that a small fluctuation might pass unnoticed if the change took place slowly; but it would hardly be thought possible that the light could be reduced to half its previous amount without the change being observed.

It was greatly to the credit of the supply companies generally that the variations were usually kept well within the Board of Trade limits; but he could mention places not very far from Albemarle Street, where he was lecturing, at which the fluctuations very much exceeded these limits. He would therefore advise consumers to have the pressure on their house mains tested on their own account at frequent intervals. The professor pointed out that the consumer could obtain legal redress if the variations in pressure exceeded the prescribed limits.

If 97 volt lamps were employed on a 100 volt circuit, then if the pressure fell to 97 volts, it would cause a loss in electrical energy to the consumer of 3 per cent., while if 100 volt lamps were employed the loss would be 21 per cent. This would point to the advisability of using lamps of somewhat lower voltage than that nominally maintained on the circuit. On the other hand, if the actual pressure were higher than that for which the lamp was constructed, it would diminish the life of the lamp, and so run up the bill for replacing lamps; for the life of a lamp depended more on the maximum than on the mean pressure at which it is run, and a lamp was rapidly destroyed when the pressure was too high, just as a gun which might last a lifetime if not overcharged, might be seriously injured or destroyed by a single overcharge of powder.

The professor then exhibited some experiments showing that the fact that any particular type of lamp had a certain definite pressure at which it would be used most economically had its exact analogue in gas illumination. Any gas burner had a certain definite pressure at which it gave the greatest amount of light for

* Abstract of the Friday evening discourse at the Royal Institution on April 8, 1892.

a given consumption, and, therefore, it was important to use regulators, as the gas regulations specified no maximum pressure, but only a minimum, and the pressure was frequently found to vary as much as 100 per cent. within 24 hours. In the case of gas lighting, the householder could regulate the pressure by means of taps, or automatically by means of regulators, while a glow lamp on a direct current main, as on the low pressure system of distribution, had to be full on or quite off in order to obtain the greatest economy. Though this counted in favor of gas, the professor observed that the gas supplied in different parts of England varied greatly in quality, while no one had yet discovered any method of adulterating electricity.

The lecturer then gave the following classification of coulomb meters, illustrated by typical forms :

The Edison Electrolytic Meter, in which electrolysis took place between a pair of zinc plates immersed in zinc sulphate, while, in order to avoid the trouble of weighing, it was made to automatically reverse the current after the passage of a known number of coulombs, and the number of reversals was automatically registered.

The Motor Coulomb Meter, in which a rotating part revolved at a speed proportional to the current strength, as would always be the case for a motor with permanent magnets. This was illustrated by measurements made with a Gramme magneto machine employed as a motor. The driving force was here proportional to the current, and the proportionality of the speed to the driving force was obtained by means of magnetic friction. In the Schallenberger meter it was obtained by means of wind vanes, in the Teague meter by means of a vane moving in glycerine, and in the Hartmann & Braun meter by means of a copper disk spinning between magnets. In the case of purely magnetic friction the smallest force would start motion, and with a large force the speed would not be very great, while with mechanical friction a certain limiting driving force had to be attained before motion would begin, after which the speed increased rapidly with the force. This was illustrated by means of a disk of copper spinning between the poles of an electro-magnet in one case and rubbing against a spring in the second case. This showed that mechanical and magnetic friction follow different laws. In either case, however, rise of temperature, and also wear, and the accumulation of dirt, would diminish the speed of the motor, which might account for the fact that motor meters were not in favor with the electrical supply companies.

Periodic Meters.—In these the current was cut off at intervals for a length of time depending on the strength of the current. The professor had set some students to find how much unrecorded energy they could get from a Frager's meter, which is of this type, by suitably timing the opening and closing of a switch, with the result that the energy obtained was between 300 and 400 times the amount recorded; these, again, therefore, would be unlikely to obtain favor with the supply companies.

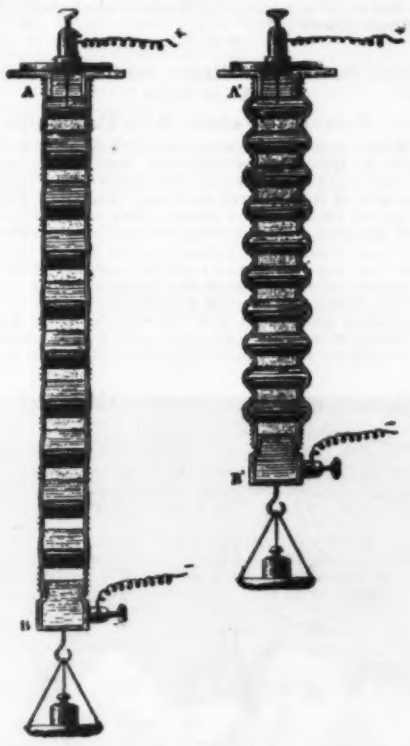
Ayrton and Perry Meter.—This meter consisted of two clocks, one of which was an ordinary timekeeper, while the pendulum of the second clock carried a coil, while a second coil was placed underneath the bob, and the current passed through both coils in the same direction. The attraction between the two coils caused this clock to lose time relatively to the other, and it was found that if the attraction did not exceed a certain definite fraction of the weight of the bob, the difference in time was proportional to the number of coulombs which had passed through the meter. They had proposed that one clock only should be contained in each meter, and its time compared with that indicated by a reliable standard watch carried by the inspector. Ayrton, in his instrument, which was constructed on the same principle, preferred to have the pair of clocks in each meter. The professor explained that this meter had been modified to record electrical energy, instead of coulombs, and stated that the Thomson-Houston Company were now constructing an improved form of it. Another form was constructed by Messrs. Richard Frères, but all the supply companies continued to use mere coulomb meters.

Great difficulty had been experienced in making coulomb meters to register as accurately as gas meters, much of the abuse of which he considered to be undeserved, and due probably to the waste caused by the variations in pressure, but these efforts had at last been crowned with success.

Passing on to the question of heating by electricity, the professor observed that at first sight it would seem that it could not possibly be economical, as the amount of energy equal to that contained in a Board of Trade unit costing 7d. or 8d. could be obtained by burning about a farthing's worth of coal. On the other hand, however, the electrically generated heat could be applied exactly where it was wanted with a minimum of waste, and a joint could be roasted without nearly roasting the cook as well, which was decidedly wasteful. Mrs. Ayrton and the professor's students had made a number of experiments. One of the results obtained was that it cost about 2d. an hour to maintain an ordinary flat iron at the proper temperature by means of a zigzag of insulated wire embedded in its face. If this were considered high, there was the set-off of the rapidity and ease with which it could be heated at short notice, the constancy of temperature attained, and absence of waste of time in taking it to and from the fire. A frying pan constructed on the same principle was raised to the temperature required to frizzle butter by the expenditure of 6·84 watt-hours, which at 7d. per Board of Trade unit would cost about a fifth of a penny. An omelette could be made in this frying pan in about a minute and a half at about the same cost. These results seemed to show that electrical heating for occasional purposes was decidedly worthy of consideration.

THE ELECTRIC ORGAN OF THE RAIA TORPEDO.

IN the course of some articles in *La Lumiere Electrique*, entitled "The Generation of Electricity by Living Beings," M. d'Arsonval discusses the nature of the source of the electric supply in animals such as the *Gymnotus electricus* and the *Raia torpedo*. The electrical apparatus of the *gymnotus*, says M. d'Arsonval, is situated underneath the animal, the positive pole being at its head, the negative at its tail. In order to give violent shocks and stun its prey at the first blow, the *gymnotus* folds itself into a circle, and completes the electric circuit through the body of the doomed animal. At the College de France M. d'Arsonval possesses a *gymnotus* which can give high pressure discharges sufficiently powerful to magnetize electromagnets. The maximum pressure is more than 100 volts and the maximum current is probably 2 amperes. In the case of the *gymnotus* the discharge is continuous and unidirectional. In the case of the *torpedo* it is not so. Some people, says M. d'Arsonval, liken these electrical organs to voltaic batteries or Leyden jars, but such analogies will not bear examination. If such were the case it would only be necessary to connect the poles for a discharge to take place. Now, it is erroneous to state that the *torpedo* invariably gives a shock



when touched. If you touch without irritating, nothing comes of it. Will governs the phenomenon. The electricity is not, so to speak, ready within the organs of electric fish; it is only generated when the animal wishes.

M. Lippmann has shown that an electric current can be generated in the following manner: Take two test tubes, place a layer of mercury in each, pour water on the top of the mercury and connect the two vessels by a cotton wick dipping into the water. On inclining the tubes a current is produced in one direction, and on bringing them back to the vertical an inverse current is observable. The phenomenon is due to variations of capillarity.

These conditions are reproduced by protoplasmic matter. If we excite the protoplasm, it alters shape and becomes a ball, and this deformation is accompanied by a negative variation, the surrounding liquid being positive. We thus have an electric current generated, bearing some proportion to the number of cellules.

It is easy, says M. d'Arsonval, to reproduce this experimentally. In the accompanying illustration a number of layers of mercury and water are shown superposed one on the top of the other in an India rubber tube. If we stretch the tube, we get an electric current. If we have several thousands of cells, and if each gives an electromotive force of only one-third of a volt, a very high potential difference is soon obtained. Here we have the reason why these organs are voluntary organs and only generate electric currents under the influence of the animal's will.—*The Electrician.*

PROTECTION OF TELEPHONE LINES AGAINST INDUCTION.*

By DOLIVO VON DOBROWOLSKY.

WITH reference to the paper read by Dr. Strecker on this subject, and which we have given in our preceding numbers, Mr. Dobrowolsky remarked that he intended to show how easy it is, by various small contrivances, to diminish, or even to destroy altogether, the inductive effects of powerful currents upon telephone lines. The author further stated that he dissented altogether from the conclusion arrived at by the telegraph engineers of the German post office, that the only possibility of avoiding disturbances in telephone lines consisted in selecting the locality for the

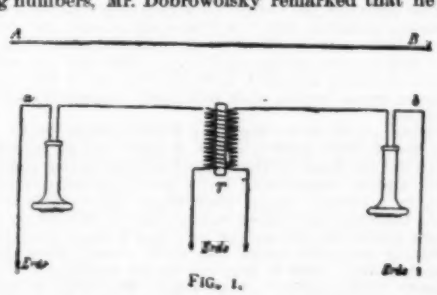


FIG. 1.

* Paper read at the meeting, March 2d, 1892, of the Berlin Elektrotechnischer Verein.—*Electricity.*

powerful current line in such a manner as to exclude interference with the telephone line.

Quite apart from the elementary self-protection, which consists in making the lines change their mutual position, with simultaneous employment of a metallic return, induction can often be rendered innocuous by small and cheap contrivances. Among these may be mentioned a method proposed by F. Neal, in 1884, which, though referring to disturbances of the telephone lines by telegraph currents, may be adapted to the prevention of induction by powerful currents. Let A B (Fig. 1) be the inducing line and *a b* the telephone line affected by it. By inserting a small transformer, T, in the middle of the induced line the currents in the second half of this line flow in an opposite direction to those in the first. The inductive effects on the part of A B are, therefore, of opposite direction and are hereby annulled. The effect of this contrivance is somewhat similar to the crossing of the outgoing and return wires, but with this distinction, that the most favorable position of the transformer can be more easily ascertained by repeated trials, so that even in the case of the induction being of varying strength no disturbing effects manifest themselves in the two portions of the line. And, further, the effects of the powerful current itself can be utilized in the following way to destroy induction. Let A B (Fig. 2)

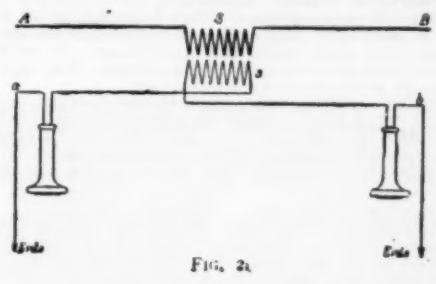


FIG. 2.

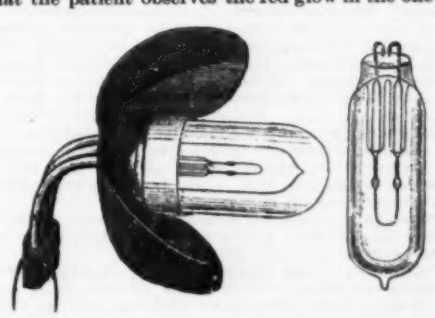
again be the inducing, *a b* the induced line, and a coil, S and *s*, be inserted in each line. These two coils may either lie one inside the other or close together and induce each other. By proper connection the induction in the coils is opposed to that in the line. By displacing the coils perfect silence can be obtained in the telephone, and one regulation is sufficient once for all; for, if the current increases in A B, it also increases in coil, S.

To demonstrate this fact, Mr. Dobrowolsky exhibited two telephone sets, made by Messrs. Keiser & Schmidt. One of the lines connecting these sets was wound on a large wooden column. In the interior of this wooden frame was a line fastened to porcelain insulators and connected to an accumulator and an automatic current interrupter. The induction, on account of the close proximity of the telephone and inducing lines, and also on account of the employment of directly interrupted currents, was stronger than will ever occur in practice, and an unbearable noise was heard in the telephone. On inserting the two coils mentioned above, and regulating their position by means of a micrometer screw, the noise became less and less and finally disappeared altogether, so that conversation could be carried on without any hinderance.

APPARATUS FOR EXAMINING THE CAVITIES OF THE FACE BY ELECTRIC LIGHT.

THE diagram illustrates a specially devised and constructed arrangement for examining the cavities of the face by electric light. The lamp is a new pattern, made by Edison and Swan, equal to five-candle power. It is mounted on the same plan as the smaller covered lamps I have used for three years or so for the purpose, but is ten times as strong as they are. The glass covering protects the mouth from undue heat or risk from accident to the lamp. Mounted in a vulcanite tray, it has free communication with the external air by the tubes, which go through the vulcanite and carry the wiry socket; in this way it is kept sufficiently cool for all practical purposes.

The chief object of the vulcanite tray is to prevent as much as possible the light escaping from the mouth through the teeth and lips into the soft tissues of the face, and interfering with the direct light through the antra, which passes with a red glow from the nostrils and from immediately under the orbits. The effect, in cases of suspected disease, is so decisive that it seems impossible to make a mistake in diagnosis, for if any obstruction exists, the darkness on that side of the face is so strong a contrast to the light on the other side that the patient observes the red glow in the one eye



The drawing of the mounted apparatus is slightly reduced; that of the lamp is full size.

and not in the other. Of course, if there is no obstruction, the light is equally visible on both sides. It is necessary to conduct the experiment in a perfectly dark room, otherwise no effect will be observed. The teeth should be well closed over the lantern on the vulcanite tray, and the lips tightly drawn over the front flange, thus leaving, outside the mouth, only the metal tubes to supply the air and carry the electric wires.

The current is taken from that supplying the house, but is reduced by a resistance coil from 100 volts to the necessary power.—*Lancet.*

THE TOCCI TWINS.

WE give an illustration of what are probably the most remarkable human twins that have ever approached maturity. They recently arrived in this country. They are known as the brothers Giovanni and Giacomo Tocci. They were born on July 4, 1875, their mother being nineteen years old. The mother's maiden name was Antonia Mezzano. Their birthplace was Locana, Turin (Italy). The same mother has had nine children, all strong and well. The twins are connected from the sixth rib downward, and have but one pair of legs and a single abdomen. The spinal columns are distinct until the lumbar region is reached. There they unite at an angle of 130 degrees. The sacrum seems to be a single bone. They have two distinct stomachs, hearts and pairs of lungs. The arterial and respiratory systems are quite distinct; the heart beats and breathing differing often in the two individuals. At the age of thirty days they weighed eight pounds, and in the next thirty-one days gained nearly three pounds.

It was at this period of their lives that they were first subjected to critical examination.

Their lives are distinct. They have regions of common sensibility, and of purely individual sensation. One often sleeps when the other wakes. There is no direct correspondence of their appetites. One may be hungry while the other is fast asleep.

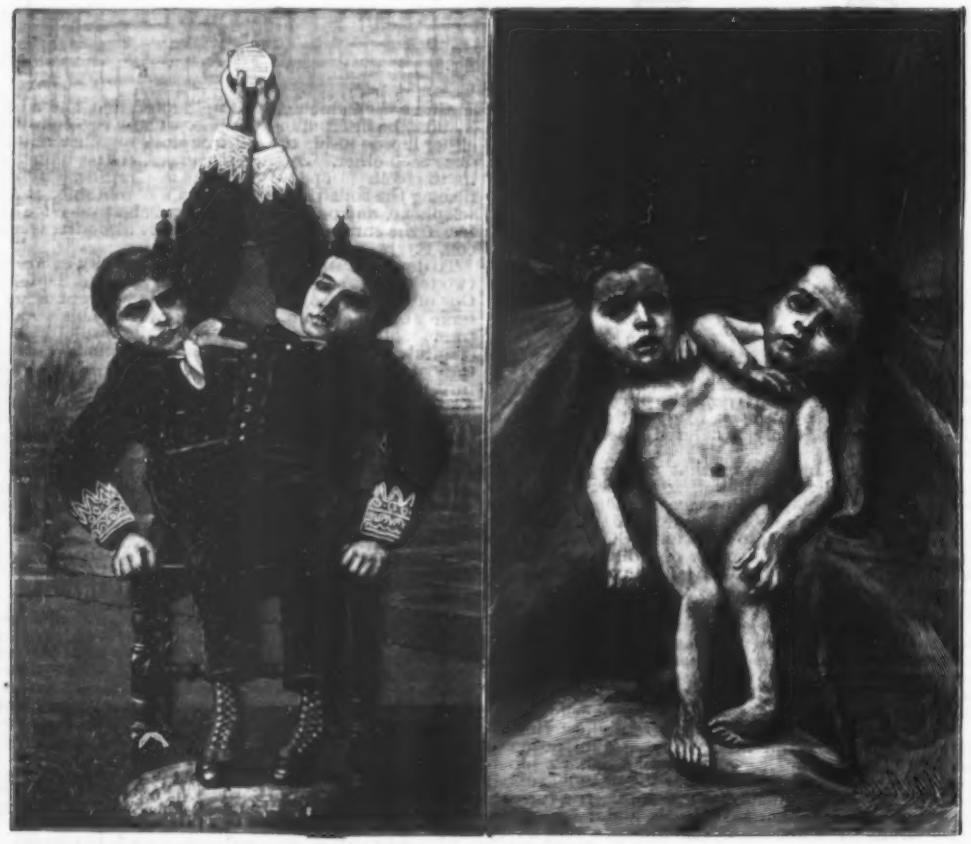
In their general appearance there is nothing repulsive. They have bright, intelligent faces, not of the peculiar cast common to cripples. They are educated, and write their names as souvenirs for visitors.

They are able to stand, but have not yet succeeded in walking, as each leg is governed by its own brain. The want of correspondence has proved fatal to any attempts in this direction. They can stand quietly, so that it is not only a question of strength. At their home they spend much of their time on the floor, using their inner arms for the most part, crawling and tumbling about and thus getting a certain amount of exercise. They can dress and undress themselves.

The one on the reader's left as he faces the picture, Giovanni, drinks beer in considerable quantities. The other one, Giacomo, not liking beer, drinks mineral water in its place. Giovanni is quite fond of sketching and draws with some spirit. He rests the book or paper on his knee. Sometimes his brother, who is more of a talker and more volatile in disposition, finding some fault with the drawing, will kick the drawing off his knee. All this in good part, for they live on excellent terms with each other, and seem unconscious of any misfortune in their condition.

They are disconnected as regards illness. Quite recently one of them had a cold, while the other was suffering from a bilious attack.

The Siamese twins Eng and Chang, who died in 1874, within a few hours of each other, at the age of sixty years, were very celebrated. They were far less completely united. A thick fleshy ligament connected the lower ends of their breast bones. They were of a good degree of intelligence, conversed with visitors, and seemed reasonably well contented with their lot. Had the uniting ligament been purely muscular they could, doubtless, have been cut apart, with survival of both persons. The possibility of doing this was often discussed in their life. But on post mortem examination it was found that a process of peritoneum extended from one abdominal cavity to the other. But one or two cases are on record of the severing of such a ligament at the time of birth, with survival of even a single member of the pair. Before the Siamese twins, the "Hungarian sisters," Helena and Judith (1701–1723), obtained much celebrity. Their region of connection was the sacrum. The South Carolina negresses, Millie and Christine, exhibited under the misleading title of the two-headed nightingale, were another interesting example of twinning. They were also connected by the lower parts of the back, including the sacrum and probably lower lumbar region. They had four legs, and were really not much more closely connected than the Siamese twins. They enjoyed excellent health and spirits and used to sing together. They progressed by walking either on the rear pair of legs or on all four, in which case they moved sidewise. Waltzing was one of their accomplishments. Unquestionably their intestines were united. While they possessed common sensory nerve systems as regards the legs, both feeling a touch, the motor nerves were so distinct that one could not move the limbs of the other. They were born about 1851.



THE TOCCI TWINS.

THE BLENDED TOCCI BROTHERS, OF LOCANA, ITALY.*

By ROBERT P. HARRIS, M.D., Philadelphia.

WE have here a nude representation of what we must regard as the most remarkable duplex monstrosity that the world has seen since the death, three hundred years ago, of their Scotch analogue, who had reached the age of twenty-eight years. This peculiar type of twins appears, on an average, twice in a century, as there have been about a dozen in the last six hundred years, and but two in the current century. The most remarkable feature about the Locana twins is that they are living and in good health at the age of fourteen and a half years, and bid fair to reach mature age, because of the perfection and independence of their thoracic and abdominal viscera. In the last six hundred years but two monstrosities of the same type have lived out their first year; and this early mortality we must attribute to a want of internal anatomical symmetry, and particularly to an abnormal construction of the heart and distribution of the blood vessels in one twin. It is doubtful if united twins are ever equals in mental and physical vigor, and the Tocci brothers are as nearly alike in health and strength as has been the case in the subjects that have lived the longest.

The photograph before us represents the boys in a standing position, but it will be seen at once that they are mainly sustained in it by the use of their arms, and that this is more markedly the case with the left twin, whose shoulder is forced upward, because of the weak support given by his club foot and imperfectly developed leg.

These twins were born in Piedmontese Italy, on October 4, 1877, after a labor of eight hours, under a midwife, the head of the right boy, Giovanni, coming first; and he appears to have held that relative position, in a mental sense, ever since. Giacomo's head soon followed, and then came the double thorax, a single abdomen, one pair of legs, and a single placenta. Nothing was said about the cord, except that there was but one; but it was no doubt composed of six vessels—four arteries and two veins. The twins weighed 8¾ pounds when a month old, and probably a pound less at birth. When three years old, as shown by a photograph, they had shoulders, a corpulent abdomen, and, for their age, large testicles. Giovanni had a long face and a girl-like appearance, but his head circumference has always been a little the larger of the two.

These xiphodidymi belong to the class that is distinguished by having two heads, four arms, and only two legs. In general outline they resemble, when their legs are together, a letter Y—the heads, shoulders and chests, down to the sixth ribs, making the V, and the abdomen and legs the I, or stem. Their present weight is 95 pounds, a healthy, robust boy of their age. Their arms, having much more exercise than their legs, are larger, in proportion to their age, than the latter; and the glutei muscles of Giacomo are badly developed, because of his talipes equino-varus, and consequent inability to develop them by exercise. Single boys of fourteen, as a rule, have much better developed legs than arms, which led to the expression in war times: "Better fitted for running away than handling a musket." But the Tocci boys are the reverse of this in strength.

If we had a back view of the monstrosity, it would show their two inner arms crossing each other over to their outer shoulders, in the position in which they usually hold them; two converging spinal sulci extending down to two sacra; two outer nates, as in a single subject; and two little rudimentary nates with a cleft between them located over the intra-sacral symphysis. They have no rudimentary nodule to represent an attempt at the formation of a third leg, as has been found in some analogues.

As they look at you, the two boys are quite different in facial contour, and Giovanni is generally credited with having the better mind; but their faces in profile bear a closer resemblance. They have fair skin, and at times a rosy color, and thick brown hair. Their bodies are short, and they are below the medium height, for their years. Their facial expression is not a happy one, when in repose, and reminded me of what I had noticed in boys having deformed feet—a shame-faced look.

In measure of health the twins compare well with normal children of their own sex, having had but little sickness since birth, and not having lost a day therefrom since they commenced to exhibit themselves in the United States, six months ago.

Giovanni is the stronger and more erect of the two, has the better ear for music, learns a foreign language the more readily, and is generally the more intelligent of the two. He has a natural talent for drawing, and is devoted to making pictures of our domestic animals, such as the horse, cow, etc., and some of the savage quadrupeds, as of the lion and tiger. Giacomo is the critic in art, although drawing but little, and his taste is for caricatures. The brothers converse a great deal together. They are both right-handed, although one might have supposed that Giacomo would have naturally preferred his free arm, the left.

The boys have each two lungs, the outer being the larger, and are forced to breathe largely by their diaphragms. They have separate and distinct hearts, located in the left chest cavity respectively, and these hearts are believed to be normal in structure. Giovanni feels his heart beating on the left side—and if either boy has an abnormal cardiac structure, he should be the one—yet his color and health indicate the contrary. The cardiac beats are not synchronous, and one heart generally pulsates a little quicker than the other.

They have two stomachs, and that of Giovanni is said to be reversed, the greater curvature being to the right, as was the case in Rita, of the Sassari girls, of 1829. I was not permitted to verify this, because of the opposition of the father. These two stomachs are as independent functionally as if they occupied two different abdomens. Recently, when traveling by railroad, one of the boys became very pale, and directly vomited the contents of his stomach,* while the other was so entirely free from nausea that he laughed at his brother for his mishap. One brother may wake up hungry, drink a cup of coffee, and eat something, while the other remains asleep. The two stomachs do not appear to be influenced in the least by being in contact, but only by their respective pneumogastric nerves.

There are evidently two sets of intestines—large and small. One boy can have a desire to defecate when the other has not; and this is particularly the case when one has a diarrhœa, in which event he only has a discharge, while the other is passive. There must, therefore, be two colons, as was found on autopsy in the Padua boys of 1691. They have probably a common rectum, as had also the Padua analogue; but it is possible that this part of the bowel may be bifid, which would be an interesting feature to determine by touch or speculum. The twins, from habit and convenience, defecate almost always at the same time.

They have two bladders and one urethra, as had also the Padua boys, although they usually urinate together. As their tastes for food and desire for drink are not the same, one boy may be awakened from his sleep in the morning by a distended bladder and empty it without waking up the other, in whom the kidneys have been less active.

My catechetical examinations made last month confirm the opinions respecting the anatomy of the twins that were formed after auscultation, percussion, and a knowledge of their habits, by Drs. Fubini and Mosso, of Turin, in their second month, and by Drs. Colrat and Rebatel, of Lyons, in their thirteenth. The conjectural belief that they might have two colons has been changed into one of knowledge, as is shown by their independence in defecation. In the event of an autopsy, these colons will no doubt be found of small caliber, and quite abnormal as to length and direction. We are warranted in this belief by discoveries that have already been made in the examination of dead analogues. Even the single colon of a double monster is quite abnormal.

The boys are quite differently affected by changes of temperature. Giovanni requires less underwear than his brother, and will perspire freely on a hot day, while Giacomo has a dry skin. Either brother may be seized with an attack of coryza, as the effect of a direct wind draught, when the other entirely escapes. They sleep upon the back—or, more correctly, each is in a dorso-lateral position, and places the side or back of his head upon the pillow. They usually sleep eight or nine hours continuously. For a change of position they sometimes turn over upon their abdomen for a short time, but never sleep in this form of decubitus.

* Dr. Harris brought to the notice of the College of Physicians an enlarged photograph of this remarkable monstrosity, which had been prepared for the Mutter Museum at the desire of its curator, and made the following remarks.—*Med. and Surg. Reporter.*

* This was repeated by Giacomo in public on April 23, 1892, at the Dime Museum, Philadelphia.

A prick with a pin in the median line of union is felt by both brothers, but the sensation is lost to one twin in passing to either side. The penis is said to have a sensation common to each, and the scrotum has a partial one beyond the median line. It is claimed that one twin feels a little when his brother's testicle is touched, which I believe to be an error, the sense being in the skin only, as the testicles are supplied with nerves through the inguinal canal. The penis and testicles are in an undeveloped state, being small for their age. The penis becomes erect, but the boys have no knowledge of its sexual function.

The two legs are entirely independent, and each belongs to, and is controlled by, the boy whose head is on the same side. One boy does not feel a touch upon the other boy's leg, and has no power, by his will, to give it the least motion. It is possible that the twins might balance themselves so as to stand, as their Scotch analogue is said to have done, if the leg and foot of Giacomo were as well formed as those of Giovanni, and had the same degree of strength that the latter appears to have.

Whether the boys have two separate livers, or a double one with two gall bladders, has not yet been ascertained, for want of permission to make the required examination. Having two bladders, they may have two pairs of vesiculæ seminales, but are more likely to have one to each bladder, with one vas deferens and one ejaculatory duct, as this would be in correspondence with the existence of one testicle to the owner of each bladder, and one urethra for the exit of the ducts. I find no reference to the seminal vesicles in any report of autopsies made in male analogues.

With regard to other viscera, we can only form an inferential opinion, as follows: The spleens are small, and located right and left to correspond with the positions of the stomachs. The pancreases have their heads facing each other, to correspond with the curve of each duodenum. The kidneys are in two pairs, the outer being large and the inner being small, or, perhaps, rudimentary. It is rare to find no trace of the two inner kidneys where the spinal columns are well separated so as to give space for them.

I see no reason why these Tocci boys may not live a number of years yet. Giovanni is the stronger, mentally and physically, but the difference is not much marked, and no special element of weakness likely to shorten life appears to have been discovered in Giacomo. They have both learned a certain measure of French and German, and both can sing, Giovanni having the higher-pitched voice. One of the Scotch twins, already mentioned as having reached the age of twenty-eight, is recorded as having been quite stupid when compared to his brother. We have no such difference to record here.

CRYSTALLOGRAPHY.

THE study of crystallography comprises two parts—one of them geometrical and the other physical. Considered from the first of these points of view, it is a special chapter of geometry in space, treating of symmetry in the polyhedrons. Symmetry, in fact, is the principle that dominates crystallography, and upon it this science was founded a century ago by the genius of Haüy. Starting from this principle, Haüy explained how the different forms of the same system can be metamorphosed into each other, and constituted the celebrated theory of *decrements*. More recently, Bravais has considered molecules as placed upon equidistant straight lines and intersecting each other in order to form parallelograms whose molecules occupy the summit. Upon this hypothesis he has founded the theory of *traces*, which Mr. Mallard has developed and made public.

As for the systems of representation of crystalline forms, they are numerous. We may, as is usually done in geometry, represent polyhedrons by their images, that is to say, make use of isometric perspective. But there are systems of projections that are more capable of permitting of the making of simple and accurate diagrams particularly useful in the cases of complex or grouped crystals. The one most employed is the stereographic. Despite their advantages, such systems cannot supply the place of drawings realized through isometrical perspective. Crystals, in fact, are not solely mathematical abstractions, but are concrete creations that nature presents to us in abundance, and, in order to recognize minerals, it is necessary to have seen as accurate a representation of them as possible. But an outline of them is inadequate, and it is in order to complete this and to habituate the eye more rapidly to complex forms that mineralogists have long had recourse to models. These are formed of various materials. Modeling clay has been used, and in the galleries of the museum there may be seen a remarkable collection of crystal forms in terra cotta made under the direction of Romé de l'Isle. Cork, which is so easy to cut, has the advantage that one can, without instruction, obtain with it the different modifications that permit of passing from one form to another. The most widely used models, it is useless to explain why, are those made of wood. But all opaque substances have one drawback, viz., it is impossible to see therein the axes that are the primordial elements of crystals. That is the reason that recourse is had to glass.

Our engraving represents some of the models of Messrs. Fribourg and Hesse's collection, which appears to us capable of rendering services in the teaching of crystallography. In Fig. 1 we see a cube presenting a series of facets under its envelope. The eight truncations executed upon the summits of the cube give, supposing them to be prolonged, a solid with eight faces or a regular octahedron. This is represented in Fig. 2, showing by transparency its three identical (quaternary) axes.

The octahedron of Fig. 3 has its three axes no longer equal—it is a quadratic octahedron, with its vertical quaternary axis and its two horizontal axes.

Fig. 4 represents the right octahedron with rhombic base (three binary axes). It differs from the preceding in that its base is a lozenge or rhomb instead of being a square. It will be remarked that this difference is not perceptible in the figure, the reason being that the perspective of a square is a parallelogram. Let us say, by the way, that we have here, precisely, a proof of the necessity of models.

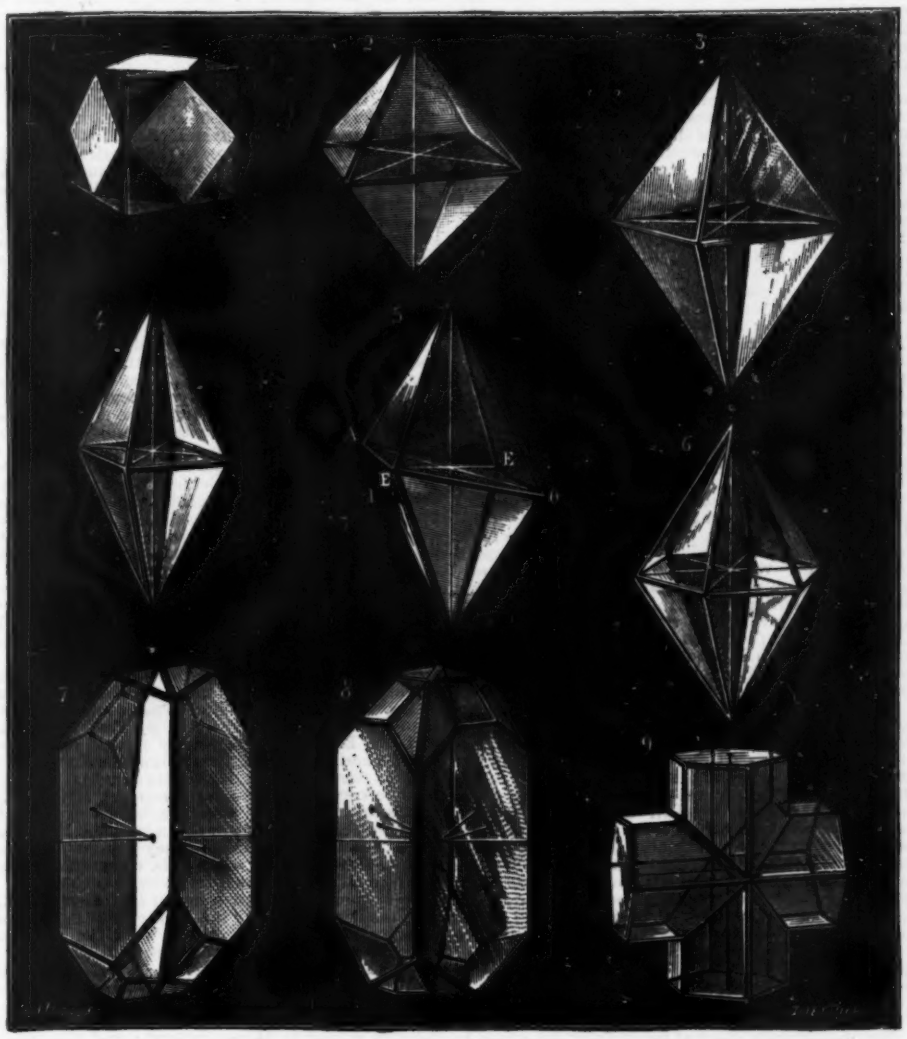
In Fig. 5, the base is no longer horizontal, but oblique. It is the oblique octahedron with rhombic base (a single binary axis). For a reason identical with the preceding this figure may be considered as also representing an octahedron whose base would be inclined in two directions, that is to say, from left to right and from back to front, thus constituting an octahedron without a symmetrical axis (asymmetrical octahedron).

The double hexagonal pyramid or dihexedron of Fig. 6 belongs to the hexagonal system; it is characterized by its vertical senary axis and its three horizontal binary axes.

Figs. 6 and 7 relate to the same crystal of the asymmetrical system provided with facets upon its edges and its angles. The crystal shown in Fig. 7 is divided into two by a plane passing through its center of symmetry—a plane formed in the model by a double plate of glass. Let us turn by 180° one of the halves of the crystal around a perpendicular to the preceding plane, and we shall obtain the form shown in Fig. 8, which is composed of two half crystals placed in the same relative position as an object and its image seen in a mirror. This is what is called in crystallography grouping by hemitropy.

Fig. 9 represents another grouping. It is a penetration of two crystals of the orthorhombic system. This form is furnished in nature by stanrotide, which derives its name from the Greek σταυρός, "a cross."

Crystallography is a science which is as yet but little cultivated; and nevertheless it presents a double interest. Its practical results are not to be overlooked, for it singularly facilitates the determination of minerals and even of chemical products. Its theory, in establishing the relations between the geometrical and physical properties of crystals, touches upon one of the most important of phenomena—the state of matter in solid bodies.—*La Nature.*



SPECIMENS OF GLASS MODELS OF CRYSTALS.

SOIREE OF THE ROYAL SOCIETY.

THE annual *soirée* of the Royal Society, which took place on Wednesday, May 4, may be said to have been the most successful that has been held for many years. *Nature* gives the following notes of the most novel and important objects displayed:

Professor T. E. Thorpe exhibited a model to illustrate the general phenomena of explosions as brought about by the presence of dust particles, in explanation of the causes of colliery explosions. This apparatus consisted of two long narrow boxes, fitted together in the form of a cross. On the bottom of these boxes was thinly strewn a quantity of fine lycopodium powder, while at one end of the longer box there was a small chamber in which a blank cartridge was fired. The firing of this cartridge corresponded to the direct action of a "blow-out shot," while the dust raised by the concussion, which carried the flame throughout the entire apparatus, took the place of the fine coal dust. The apparatus also showed that the progress of such an explosion was always accompanied with increase of violence.

Professor Clowes showed an ordinary miner's safety lamp which had, by a very simple contrivance, been converted into a delicate instrument for detecting minute proportions of fire damp. To the ordinary burner an additional tube is made to pass through the oil reservoir, one end of it being connected, by means of a flexible tube, with a small portable bottle of compressed hydrogen. The hydrogen when turned on becomes ignited close to the oil burner, the flame of which is extinguished by turning down the wick; by adjusting the flame of hydrogen to the standard height, a luminous column of light is seen vertically over it, from the behavior of which the amount of inflammable gas can be directly estimated. At the conclusion of the experiment the wick is simply turned up, and ignited from the hydrogen flame; the latter is then disconnected from the bottle. From 0·25 to 3 per cent. of fire damp has in this way been estimated, while greater quantities than these have been measured by reducing the size of the flame.

Vacuum tubes without electrodes, exhibited by Dr. Bottomley. These tubes, which were of a variety of shapes and kinds, illustrated very beautifully all the phenomena of stratification. They were sensitive also to magnetic and electro-dynamic influence, and showed the phenomena of molecular bombardment. The brilliant illumination of a piece of Iceland spar contained in a glass sphere afforded an excellent means of displaying the electrical excitements. [For an account of experiments with vacuum tubes, see a letter by Mr. Bottomley in *Nature*, January 6, 1881, vol. xxiii., p. 218.]

Mr. Cecil Carus-Wilson exhibited some natural and artificial sands, from which he was able to produce many musical notes. These notes, as he explained, were the results of the rubbing together of the surfaces of the grains of sand, but he had met with several sands from which he could not obtain a vestige of a note. One special artificial sand sang only when rubbed in some sort of vessel.

Apparatus for measuring degrees of incompleteness of color vision, exhibited by Mr. Brudenell Carter. The object used for the tests is a group of various colors, which were such that they could be seen by either reflected or transmitted light. The amount of illumination that was required to recognize the colors distinctly was a measure of the "degree of incompleteness." In order to control this amount of illumination, light of known intensity had to pass through a variable aperture before it fell on the test object, the size of this aperture being read off in square millimeters.

Captain Weir's azimuth diagram was exhibited by Mr. J. D. Potter. It is claimed for this diagram that, besides being most ingenious, it furnishes one of the most successful modes of graphic solution of a mathematical problem that has ever been invented. It is used for finding the true azimuth of a heavenly body, taking into account the ever-changing errors of the compass, which in our days of iron ships have to be so carefully watched and recorded. The errors as usually determined are obtained from observations made of the compass bearing of a heavenly body (the sun generally being taken) with its true bearing, and it is for the

simplification of this method that this azimuth diagram has been found to be practically useful.

Professor Oliver Lodge had three exhibits. The first was the projection of interference bands on a screen, being produced by a modified method of Michelson. Very striking also were the electric sparks in and to water, illustrating lightning effects and multiple flashes. In a shower, with too great spark length for a strong discharge, a multitude of violet streams or spurts filed the air, resembling somewhat lightning flashes. The spark to water spread itself out over the surface, showing that the surface layer was a feeble dielectric, while the spark under water was brief but very violent, treating the water as a dielectric, and producing concussion. The electric retina, illustrating the possible meaning of the rod-and-cone structure, was very interesting; radiation from spheres which were in a suddenly disturbed and oscillatory electrical condition falling upon a graduated series of end-on cylinders, which responded by vibrating transversely.

Mr. W. Crookes repeated many of those beautiful experiments of electric currents of high potential and extreme frequency that were first carried out by Tesla. The discharges from a battery of Leyden jars were sent through the primary wire of an oil induction coil. The frequence of alternation amounted to no less than 1,000,000 a second, while the electro-motive force reached the enormous amount of 100,000 volts. Perhaps it was as well that this frequency was great, otherwise the physiological action might have been rather surprising to those who trusted implicitly in Mr. Crookes. The resistance offered by the sheet of vulcanite to the strong current produced some fine flashes, while very pretty were the examples of brush discharges, St. Elmo's fires, etc., at the secondary poles of the oil induction coil.

The electrical apparatus shown by Captain Holden, R.A., consisted of some very important new instruments, among which we may mention the high-speed chronographic pen for taking a number of successive records of short intervals of time, the pen being automatically reset after each record; an improved simple compensated voltmeter on the hot wire system, and the dead beat alternating current ammeter worked by a heated metal strip and free from self-induction.

Prof. Roberts-Austen exhibited a new electrical method for the exact determination of very high temperatures, which has rendered possible the construction of a very simple instrument, devised by Prof. H. Le Chatelier, that can be placed in the hands of any workman. The latter depends on the comparison of the intensity of the radiation emitted by a glowing body (the temperature of which has to be determined) with that of a standard source of light. To use the instrument it is pointed in such a direction as to have the light from the heated mass of metal in its field of view, so that the color can be distinctly observed; in the same field of view a series of standard colors can also be made apparent (situated side by side with the heated metal), by turning a milled head screw which carries a pointer over a graduated scale. By matching the colors a direct reading of the position of the pointer gives the required temperature.

The Rev. F. J. Smith exhibited an electric tram chronograph which he had devised for measuring small periods of time, varying from one-fourth to one-twenty-thousandth part of a second. This instrument consists of a metal girder furnished with a T-shaped end, carries two steel rails, and is supported on a V-groove, hole, and plane system. The carriage, on which is fixed a slightly smoked glass plate, runs on these rails, driven either by a weight or by a coiled spring. A metal pillar, carried on a V-groove, hole, and plane system, is placed in front of the moving surface, and supports electro-magnetic styli which can be brought into contact with the smoked surface; a tuning fork also is so placed that the traces are found to be recorded on the smoked plate so as to afford a means of measuring the time intervals. The two motions of the pillar, of rotation and vertical translation, allow a large number of observations to be made on the same plate. There are also continuous contact breakers, whereby, when a photographic plate is fixed in the carriage, spark photographs of moving objects may be obtained. This instrument has been applied to the measurement of the velocity of projectiles, and small periods of time in physiological research, and to the photography of insects and the falling drops of liquids.

Perhaps the most unique exhibit of the evening was the series of photographs of flying bullets which Mr. Boys had obtained by a modification of an old method. The photographs showed beautifully the waves in the air caused by the rapid flight of the bullet analogous to those produced by a fast-going steamer. In one slide the small pieces of paper through which the bullet had passed were also seen plowing their way through the air, producing quite as definite waves as the projectile itself, only of not such large dimensions. The passage of a bullet through a piece of wire was also very curious, the piece of wire that was cut off not having time to fall before it was seized by the lightning eye of the camera. The photograph showing a magazine rifle bullet piercing a glass plate brought out some very interesting facts. The glass appeared to be thoroughly scattered in a direction opposite to that in which the bullet was proceeding, the greatest scattering taking place on the side which the projectile touched first. The waves set up on the glass plate gave measures of the wave length of the tremor caused, and the velocity of travel. The bullets used for these pictures were of various kinds, and the velocities varied from 750 to as much as 3,000 ft. per second, the former from a pistol and the latter from a magazine rifle, the bullet being composed of aluminum to obtain this great velocity.

The committee of the Kew observatory exhibited a testing camera for photographic objectives that had been designed by Major L. Darwin. With this instrument all the most important features of a lens can be accurately and swiftly determined. We may mention here that arrangements are being made that any lens sent to them will be thoroughly examined in all respects under the superintendence of Mr. G. M. Whipple, certificates of examination being made out, as is at present done in the case of other instruments.

We must now pass on to the photographs.

Astronomy was well to the fore with the exhibits of Messrs. Lockyer and Roberts. The former showed a fine spectrum of Nova Aurigæ, that had been enlarged twenty-five times from a negative taken with only a 6 in. object glass and prism by the brothers Henry and Hilger respectively; several fine photographs of stellar spectra illustrating the main evolutionary types according to the meteoritic hypothesis, and photographs of the 3 ft. reflector at Kensington that is now near completion. Mr. Roberts showed some photographs of celestial objects; the original negative of Nova Cygni, taken with a 20 in. reflector with a two hours' exposure, showing the Nova as a star of the thirteenth magnitude. An enlargement of the region in which Nova Aurigæ was situated when the star was of the fourth magnitude was also displayed, together with the original photograph taken with the instrument before mentioned, but with an exposure of three hours.

The photographs showing the great sun spot of February last, exhibited by the solar physics committee, may be said to be the best series that has ever been obtained. The series included nine days, and showed the remarkable changes that occurred during the interval from February 5 to February 17.

Mr. W. Saville-Kent exhibited a series of photographs, over a hundred, taken by himself, enlargements of the same, and water color sketches illustrating coral reefs, coral animals, and the marine fauna generally of the Great Barrier district of Australia. A lantern exhibition illustrating the same subject was also included in the evening's programme. The reef views, which portrayed extensive areas of growing corals of innumerable varieties, were, as explained by the exhibitor, taken at abnormally low spring tides, and are, as a matter of fact, very rarely visible to the extent depicted.

Among the more important points associated with this exhibit were the facts that in a large number of instances accurate measurements had been taken of the individual corals that composed the reefs photographed, such reefs being in easily accessible positions, where their subsequent amount and rate of growth could be periodically determined. This exhibit, more particularly with relation to the illustrations of living coral polyps—those of the mushroom corals, genus *Fungia*, being particularly noteworthy—represented the first occasion in which photography has been systematically applied to this highly interesting biological subject. A second novelty exhibited by Mr. Saville-Kent was a pearl of fine quality and considerable size that the exhibitor had caused the mother-of-pearl shell animal, *Meleagrina margaritifera*, to produce by means of a delicately-manipulated operation on the living animal.

From the Zimbabwe ruins, Mashonaland, some very valuable finds in the shape of pottery, gold crucibles, weapons, ingot moulds, etc., were exhibited by Mr. Theodore Bent and the Royal Geographical Society; while by the same exhibitors were shown a model of the circular temple at Zimbabwe, built of small blocks of granite without mortar; and several plans of ruins in Mashonaland. No less interesting also were the photographs of ancient Central American monuments and buildings from the ruins at Chichen Itza (Yucatan), Palenque (Chiapas), etc., exhibited by Mr. Alfred P. Maudslay; and a selection from the proof plates to the first memoir of the archæological survey of Egypt that is being undertaken by Mr. Percy E. Newberry. One of these proof plates showed all the successive stages of a wrestling match between a black and a white man, more than a hundred different positions being recorded; the white man, we are sorry to say, seemed to be getting the worst of it in many of them.

Several important discoveries were made during the Royal Dublin Society's survey of the fishing grounds on the west coast of Ireland; specimens of several fish then obtained were exhibited by Prof. A. C. Haddon and Mr. E. W. L. Holt. Many new to British waters were found, while one quite new to science (*Nettophichthys retropinnatus*, Holt) was caught.

Some very curious worms composed Mr. F. E. Beddard's exhibit. They were specimens of *Branchiura Sowerbii*, and were found in a tank in the Regent's Park Botanical Gardens. They possess a dorsal and ventral series of contractile gills, which make them differ from all other known fresh-water worms.

To summarize shortly a few of the other exhibits, we may mention Messrs. Pike & Harris' high tension apparatus; Mr. H. L. Caliendar's platinum resistance pyrometers; the original specimen of *Asteropecten Orion* (Forbes), and a specimen of a slab of mountain limestone, Bolland, showing the passage of a foraminiferal ooze into crystalline calcite, by Prof. W. C. Williamson; Prof. Percy Frankland's crystals of active calcium glycerate (lævo-rotatory); and the two exhibits of turacin, one by Dr. C. A. MacMunn, showing the very remarkable spectrum it produces; the other by Prof. A. H. Church, who discovered this red pigment in the wing feathers of certain plantain eaters or Touracos. A very ingenious process of so-called color photography was explained by Mr. F. Ives, of Philadelphia, who showed several pictures by means of a special optical lantern.

A CENTURY OF AMERICAN WEEDS.*

THEIR ROOT SYSTEMS TABULATED.

By BYRON D. HALSTED.

WEEDS, it is claimed, do their greatest damage to crops by robbing the soil of those food elements that would otherwise go to the building up of the legitimate plants. If this be true, and the conclusion is a reasonable one, it follows that the root system of these "sappers and miners" is of special importance.

During the past summer, in the making of a collection of a hundred worst weeds as an economic herbarium to be distributed to the agricultural colleges, experiment stations and other institutions, particular attention has been given to the subterranean portion of each species, and, with very few exceptions, the root system, entire as possible, is shown with each specimen. In this respect the collection is unique, thanks to the untiring patience and deftness of Mr. J. A. Kelsey, my assistant, who has performed in large part the painstaking labor of collecting, pressing, and mounting the specimens.

A prolonged study of the century of specimens, or, more accurately, the fifty or more specimens of each of the hundred species, has led to a classification of the root systems as presented in the accompanying table. The first division of the plant is upon their duration, namely, into those with perennial, those with biennial, and those with annual roots. Next, under each of these heads the root systems are again divided into those with tap root prominent, with roots in a cluster (fascicled), and those with the two systems more or less evidently combined. Under each of these heads the roots are again classified as to their size—figure 1 standing for the largest, 3 for medium, and 5 for the smallest, while 2 and 4 are midway from the middle size in their respective directions in the scale.

TABULATION OF ROOT SYSTEM OF WEEDS.

		Tap Roots.	Fascicled.	Mixed.	Totals.
Perennials,	1=	10	1	0	11
	2=	5	4	4	13
	3=	3	4	1	8
	4=	0	2	0	2
	5=	0	0	0	0
Total,		18	11	5	34
Biennials,	1=	9	0	0	9
	2=	1	2	0	3
	3=	1	1	1	3
	4=	1	0	0	1
	5=	0	1	0	1
Total,		12	4	1	17
Annuals,	1=	1	0	0	1
	2=	16	0	3	19
	3=	9	6	2	17
	4=	2	4	2	8
	5=	0	4	0	4
Total,		28	14	7	49
				Grand total,	100

Of those with the roots of the largest size, that is class 1, there are of perennials eleven, biennials nine, and annuals one; and all of these are with tap roots except one, and that is a perennial with a large mass of roots extending in all directions. The plant in question is none other than the live-for-ever (*Sedum telephium*, L.), which is able to propagate by means of its roots when broken into small pieces by implements for land cultivation. The ten perennial weeds with conspicuous tap roots are: *Saponaria officinalis* (bouncing bet), *Hypericum perforatum*, L. (St. John's wort), *Arctium Lappa*, L. (burdock), *Cnicus arvensis* (L.), Hoffm. (Canada thistle), *Taraxacum officinale*, Weber (dandelion), *Apocynum cannabinum*, L. (dogbane), *Convolvulus arvensis*, L. (bindweed), *Convolvulus sepium*, L. (bracted bindweed), *Ipomœa pandurata* (L.), Meyer (man-of-the-earth), and *Rumex crispus*, L. (dock). This is a big-rooted set of perennials named in the order that they appear in "Gray's Manual." The wild potato vine (*I. pandurata*) sometimes has a root that attains the size, and occasionally the form, of a boy's body, and weighs thirty-five pounds. Belonging to the same family are the two species of *Convolvulus*, and all are related to the sweet potato and yam, which are grown for their large roots. All three of these weeds are eradicated with great difficulty, because of the perennial nature of the large, deeply buried roots. The *Apocynum* is, perhaps, the least abundant of the weeds named above, but is remarkable for the size and persistence of its roots when once established in cultivated ground. The dandelion is familiar to all, and its tap root, enormous for the size of the plant, rivals that of the burdock, a member of the same great family of plants. The Canada thistle has a root system peculiar to itself, and renders the plant particularly difficult to eradicate, the depth to which the long roots descend in the rich, loose soil being many feet. It only remains to say that the St. John's wort is not an easy pasture weed to pull on account of its deep anchorage, and the dock is likewise noted for its size and length of root.

The list of big-rooted biennials consists of: *Medicago lupulina*, L. (nonesuch), *Œnothera biennis*, L. (evening primrose), *Daucus carota*, L. (wild carrot), *Pastinaca sativa*, L. (parsnip), *Dipsacus sylvestris*, Mill. (teasel), *Cynoglossum officinale*, L. (hound's tongue), *Echium vulgare*, L. (blue weed), *Verbascum Blattaria*, L. (moth mullein) and *Verbascum Thapsus*, L. (mullein). For the size of its aerial portion the blueweed or viper's bugloss is perhaps the largest rooted biennial, but this is closely followed by the carrot and parsnip among the lower weeds, and by the evening primrose, teasel, and the mulleins for the larger species of the group. From the biennial nature of these plants it follows that, if they are kept from seeding, the land will soon be rid of them. The weeds having tap roots ranking in the second size number twenty-two, as follows: Perennials five, biennials one, and annuals sixteen, thus showing a large number in the last group. The perennials are: *Malva rotundifolia*, L. (mallow), a low plant with a stout, woody tap root; *Passiflora incarnata* (passion vine), a deeply rooting noxious weed of the Southern States; *Cichorium Intybus*, L. (chicory), a tall and deeply-anchored plant. *Brunella vulgaris*, L. (heal-all), and *Nepeta cataria*, L. (catnip) are the other two perennials of this class, both belonging to the mint family. The catnip being the larger weed, as might be expected, it has the greater root. There is only one biennial in group 2, namely, *Barbarea vulgaris*, R. Br. (yellow rocket), which has a strong root like the chicory and mallow.

The annuals, while not above the average in size, make a considerable list as follows: *Brassica nigra*, L. (black mustard), *Capsella Bursa-pastoris*, (L.) Mœnch. (shepherd's purse), *Lepidium campestre* (L.), R. Br. (field pepper grass), *Lepidium Virginicum*, L. (pepper grass), and *Sisymbrium officinale* (L.), Scop. (hedge mustard)—all of the same family, the Cruciferæ, and very much alike in root habit. *Lychnis Githago* (L.), Lam. (corn cockle), is a tall, slender weed of the grain fields, and *Abutilon Avicennæ*, Gaert. (velvet leaf), a rank pest of cultivated ground. Among the Compositæ there are *Anthemis Cotula*, L. (mayweed), and *Xanthium Canadense* (Murr.), Gray (cocklebur), plants quite different in their size and capacity for mischief. *Datura Tatula*, L. (thorn apple), and *Solanum Carolinense* (horse nettle) are two members of the nightshade family, the former a tall, much-branched, rapidly-growing weed and the latter a low

* From the Bulletin of the Torrey Botanical Club.

spinose pest. There are three of the pigweeds, namely, *Amarantus albus*, L. (tumble weed), *A. chlorostachys*, Willd., and *A. retroflexus* (common pigweeds), all of which have similar sizable roots, as has likewise their cousin, *Chenopodium album*, L. (goose foot). The last of the list is *Polygonum Convolvulus*, L. (bind weed), a miserable vine that is strongly and deeply rooted.

There are six species in the group of weeds with moderately large root systems belonging to the fascicled type. Four of these are perennials, as follows: *Asclepias Syriaca*, L. (milk-weed). When grown in its best estate in the rich prairie soil, this should, perhaps, be ranked in the first group. The plant, as a whole, is large, and grows in thick patches; the big roots make it difficult for the plow to be drawn among them. *Linaria vulgaris*, Mill. (toad flax), fills the soil with a mat of fibrous roots, some of which are of considerable size. *Polygonum dumetorum* var. *scandens* (L.), Gray (climbing buckwheat), has also a similar root system. The quack grass (*Agropyrum repens* (L.) Beauv.), is notorious for its roots so called, which are, strictly speaking, a mass of tough underground stems from the joints of which small fibrous roots proceed; taken as a whole, however, the root system is large and merits the place assigned.

Of the biennials there are only two in this group of the second class, namely, *Melilotus alba*, L. (white melilot) and *Erigeron strigosus*, Muhl. (fleabane), both of which are abundantly provided with a mass of small roots.

Passing now to the mixed system, it is found that there are seven distributed among the perennials and annuals; of the former there are *Leonurus Cardiaca*, L. (motherwort), the two plantains, namely, *Plantago lanceolata*, L., and *Plantago Rugelii*, DC., and the *Rumex Acetosella*, L. or sorrel. While the first three have roots quite alike, that is, with a more or less strong, downward, central root, and several others springing directly from it near the crown, the sorrel develops its roots horizontally and near the surface of the ground. The three annuals in group 3 with mixed roots are: *Solanum rostratum*, Dun. (Texas horse nettle), *Amarantus blitoides*, Wats. (spreading fig weed)—both low prostrate plants—and *Chenopodium ambrosioides*, L. (goosefoot).

Of the weeds with medium sized tap roots there are three species, namely: *Helenium tenuifolium*, Nutt., *Nepeta Glechoma*, Benth., and *Acalypha Virginica*, L. The first is one of the worst weeds in the Southern States, according to Prof. Tracy, who contributes the specimens to the century. In the second or ground ivy, we have a plant that forms dense masses of low growth in neglected places; while the third, the three-seeded mercury, is a widespread and common weed in moist land, particularly meadows. In the biennials of this group there is but a single species, namely, the *Echinospermum Lappula*, Lehm. (stickseed), which, while a medium sized weed, is exceedingly annoying to live stock, particularly sheep, on account of its bur-like seeds.

The annuals with average sized roots are more numerous than in the other two groups, and include the following: *Brassica Sinapistrum*, Boiss. (charlock), *Raphanus Raphanistrum*, L. (wild radish), *Hibiscus Trionum*, L. (bladder ketmia), *Mollugo verticillata*, L. (carpet weed), *Diodia teres*, Walt. (button weed), *Sonchus oleraceus*, L. (sow thistle), *Polygonum aviculare*, L. (knotgrass), *Euphorbia Preslii*, Guss. (spurge), and *Euphorbia maculata*, L. (spotted spurge). It will be seen that this is a variable set, varying in size from the charlock and its cousin, the wild radish, down to the prostrate carpet weed and spotted spurge. All form seed in great abundance, the ketmia in large capsules, the sow thistle in heads and provided with airy balloons, but most of the species have inconspicuous seed vessels.

In the group of perennials with medium sized fascicled roots, there are four species to mention, namely: *Ranunculus acris*, L. (tall buttercup), *Hieracium aurantiacum*, L. (orange hawkweed), *Rudbeckia hirta*, L. (cone flower), and *Cyperus rotundus*, L. (coco grass). The buttercup is an old weed of the grass land, while the hawkweed is a comparatively newcomer, and is spreading rapidly. In the cone flower we have a prairie weed that has spread eastward rapidly, and vies with the common daisy for the occupation of the meadows. In the coco or nut grass there is a very difficult pest to eradicate, on account of its "nuts" below ground, which serve to spread the weed. There is but a single biennial to be mentioned here, but it is a very common one—the *Erigeron Canadensis*, L. (fleabane or horseweed). The annuals again are the largest in number, there being six, as follows: *Anthemis arvensis*, L. (chamomile), *Erechthites hieracifolia* (L.), Raf. (fireweed), *Polygonum Pennsylvanicum*, L. (smartweed), *Bromus secalinus*, L. (cheat or chess), *Panicum Crus-galli*, L. (barnyard grass), *Panicum sanguinale*, L. (crab or finger grass). The chess has the greatest variety as a weed; the fireweed is the rankest grower in places suited for it, and the two *Panicums* are almost everywhere.

In the group with the root somewhat below the average in size, there are for the tap-rooted sorts only one for the biennials, namely, *Lamium amplexicaule*, L. (dead-nettle), and two for the annuals, as follows: *Stellaria media* (L.), Smith (chickweed), *Portulaca oleracea*, L. (purslane). These are all small plants, the dead-nettle or henbit reaching the highest from the ground, while the purslane is a succulent prostrate weed.

In the fascicled group for the size called number four, there are two species, namely: *Ranunculus bulbosus*, L. (buttercup), and *Chrysanthemum Leucanthemum*, L. (ox-eye daisy). It is somewhat of a surprise to find the root system of the common daisy comparatively small. It is only when the plant is old and has developed many flower stalks in a cluster that the roots become of a size to interfere at all with cultivation. Among the annuals there are four species with similar root systems, all of which are among the grasses, namely: *Bromus tectorum*, L. (chess), *Panicum capillare*, L. (witch grass), and the fox-tails, *Setaria glauca* (L.), Beauv., and *Setaria viridis* (L.), Beauv. Ordinary plants of any of these four grasses when grown separately make but a small cluster of fibrous roots.

Of those with a combination of the tap and clustered form of rooting in group four there are only two and these are both annuals and closely related, namely: *Ambrosia artemisiæfolia*, L. (ragweed), and *Ambrosia trifida*, L. (horseweed). These, from their large size, have root systems that are more extensive than those of many other weeds mentioned in previous groups, but in this classification it has been relative rather than absolute size that has governed in the classification. The rag-weeds have a comparatively small root system.

In the last group, namely, those with the smallest root system, there are but few examples. Among the biennials there is but one, and it, *Allium vineale*, L. (wild onion), is a vile pest in many dairy regions. Aside from the bulb, there seems to be little else below the ground. There are four of the annuals that are here grouped, namely: *Veronica peregrina*, L. (speedwell), *Orobanche ramosa*, L. (broom rape), *Cenchrus tribuloides*, L. (sand-bur), and *Eleusine Indica* (L.), Gaertn. (wire grass). The speedwell is a short-lived weed of early summer. In the broom rape we have a parasitical pest of the hemp and some other field crops, while the last two species are grasses, one a native and particularly obnoxious on account of its spinose fruit, while the last on the list is a foreigner that is growing in numbers but not in favor among us.

[Since writing the above one change has been made in the century, namely: the substitution of *Physalis Virginiana*, Mill., for *Polygonum dumetorum*, var. *scandens*, which does not affect the classification materially.]

Rutgers College, December, 28, 1891.

PROTEA NANA.

THIS interesting and elegant little Cape shrub has flowered every spring during the last five years or so in the house devoted to South African plants at Kew. While lacking the attractions of the azalea and the best of the Cape heaths, it nevertheless possesses a quiet beauty of its own. It may be described as a little pine-like wiry-stemmed plant, with elegant linear leaves and nodding branches, each of which bears a flower head, which in the bud stage is exactly like a little red cone, and when fully expanded scarcely like any other known garden flower. It is a shallow cup, about two inches in diameter, composed of several rows of rigid petaloid bracts colored deep crimson. The disk is composed of numerous small yellow flowers (the inflorescence being really composite in character) with pink exserted stigmas. The heads remain perfect for about a month, and are quite ornamental. The plant is cultivated along with Cape heaths, and thrives under the same kind of treatment as suits them.

PROTEA NANA—FLOWERS NATURAL SIZE.

The genus Protea is peculiar to South Africa. It is composed of about sixty species, some of which are large laurel-like bushes, while others are quite small. Generally the flowers, or, to be strictly accurate, the flower heads, are large and very attractively colored, so much so that in the early part of the present century, when Cape plants generally were quite the rage, most of the proteas were favorite garden plants in this country. Now they are scarcely known, even in botanical collections. A few years ago there was considerable excitement at one of the meetings of the Royal Horticultural Society at South Kensington when some one sent a plant in flower of P. cynaroides, whose huge flower head resembles that of an artichoke, as is indicated by the specific name. There are about half a dozen species of protea in cultivation at Kew, P. cynaroides among the number, and it blooms every year in the succulent house. But the most beautiful species are now known in England only by their portraits in the earlier numbers of the *Botanical Magazine*, *Andrews' Botanical Repository*, etc. Judged by the few we have under cultivation now, the proteas generally ought to be fairly easy to manage. The difficulty is in obtaining them. A hundred years ago South Africa was as thoroughly ransacked by the collector and botanist in the interests of European horticulture as the haunts of the most popular orchids are at the present time. Now it is difficult to induce any one in South Africa to pay any attention to such trifling matters as seed collecting.

Sir Joseph Hooker said a few years ago with reference to the proteas as garden plants: "The Cape Proteaceæ, the favorite of our grandfathers, may be said to have gone out of cultivation, so completely have they been replaced by other tribes of more or less deservedly popular, but neither more interesting nor more curious, plants. This neglect of a whole genus of most conspicuous plants which forms a grand feature of one of England's greatest colonies is not due to want of beauty, for some of them are among the handsomest of plants, whether for size, form, or color of inflorescence, and would carry away the first prize at any horticultural show. Of these, however, the present, and even past, generation of horticulturists know absolutely nothing. Nevertheless, that these and many other plants requiring similar treatment will be reintroduced, and will be the wonders of the shows for many successive seasons, is as certain as that they were once the glories of the old flue-heated houses that our forefathers called stoves, in which orchids quickly perished and banksias and proteas throve magnificently."

I have seen several of the most beautiful of the proteas growing in the southeastern regions of the Cape, where they are universal objects of admiration, one species, viz., P. cynaroides, being so abundant in some districts near Grahamstown that when its huge, rich pink heads are at their best, the colonists arrange a picnic among the flowers, pretty much as we do here for the chestnuts at Hampton Court. P. speciosa and P. coccinea are also beautiful in that part of the Cape. Here is an opportunity for an amateur to distinguish himself by reintroducing proteas into English gardens. —*W. Watson in the Gardeners' Magazine.*

MUSK SEEDS.

MUSK seeds now form a regular article of commerce, and are quoted among other products in the ordinary trade lists; they are sometimes known as "graines d'Ambrette," and are the produce of *Hibiscus Abelmoschus*, a plant growing to a height of from two to four feet, belonging to the mallow family, and widely distributed, both naturally and by cultivation, in nearly all tropical countries. The plant is generally known as the musk mallow, in consequence of the seeds possessing the well known strong musky odor which makes them valuable, or rather applicable, for perfumery purposes. These seeds are small kidney-shaped or reniform, marked with parallel ridges, and when dry of a brown color. In the West Indies the plant is known as the musk-ochra, and so long ago as the middle of

the last century the seeds were not only known and valued for their perfume, but were also supposed to have medicinal properties, and had a high reputation as a cure for the bites of venomous reptiles. Lunan, in his "Hortus Jamaicensis," says: "The seeds, when grown to full maturity, have a strong and perfect smell of musk, a few grains being sufficient to perfume a whole room. Barham says these seeds are a good cure for stinking breath, and are cordial and expellers of wind. Browne observes that they may be used with great propriety in powders and pomatums, nor does he doubt that they may be used in emulsions and many medicinal cases." The seeds yield about 6½ per cent. of an odorous principle and resin. They were used many years ago in English perfumery as a

MUSK MALLOW (HIBISCUS ABELMOSCHUS.)

1. Section of fruit. 2. Seed.

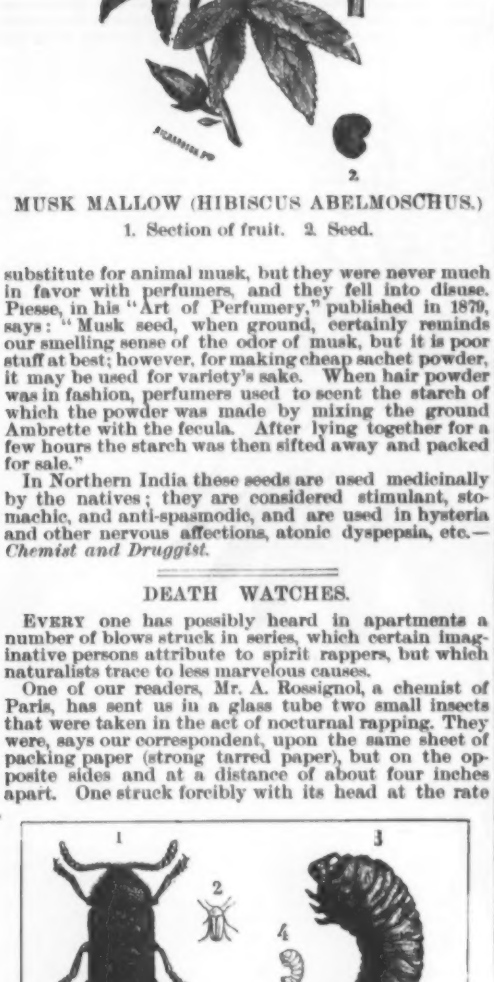
substitute for animal musk, but they were never much in favor with perfumers, and they fell into disuse. Piesse, in his "Art of Perfumery," published in 1879, says: "Musk seed, when ground, certainly reminds our smelling sense of the odor of musk, but it is poor stuff at best; however, for making cheap sachet powder, it may be used for variety's sake. When hair powder was in fashion, perfumers used to scent the starch of which the powder was made by mixing the ground Ambrette with the fecula. After lying together for a few hours the starch was then sifted away and packed for sale."

In Northern India these seeds are used medicinally by the natives; they are considered stimulant, stomachic, and anti-spasmodic, and are used in hysteria and other nervous affections, atonic dyspepsia, etc.—*Chemist and Druggist.*

DEATH WATCHES.

EVERY one has possibly heard in apartments a number of blows struck in series, which certain imaginative persons attribute to spirit rappers, but which naturalists trace to less marvelous causes.

One of our readers, Mr. A. Rossignol, a chemist of Paris, has sent us in a glass tube two small insects that were taken in the act of nocturnal rapping. They were, says our correspondent, upon the same sheet of packing paper (strong tarred paper), but on the opposite sides and at a distance of about four inches apart. One struck forcibly with its head at the rate



THE DEATH WATCH.

1. Perfect insect, enlarged. 2. Natural size. 3. Larva, enlarged. 4. Natural size. 5. Wood attacked by the insect.

of six blows per second, and the insect on the lower side answered as soon as the other had finished.

The insect sent by Mr. Rossignol is the *Anobium tessellatum* of Fabricius, a coleopter of the family *Ptinidæ*. We give a figure of it herewith.

The habits of this insect have been well studied by Becker, Taschenberg and other authors. It is generally during the night that it produces the ticking sounds in question, and as, in order to hear these, we must not go to sleep, and as usually when we do not sleep we are more or less inclined to melancholy, the *Anobiums* have been named death watches.

In order to produce the blow, the insect draws in the antennæ and intermediate legs, and, resting principally upon the median legs, strikes its head against its support by a sort of rocking motion. It is through this noise that the male calls the female.

The larva of the *Anobium* lives in wood (framework, old furniture, etc.) which it gnaws in the interior without anything outside betraying its presence. On reaching its complete development, it hollows out a cavity and becomes transformed therein into a chrysalis. The perfect insect comes forth a few weeks afterward, and makes its exit from the wood by boring a perfectly cylindrical hole in it, which thereafter shows that the wood has been attacked; and it is often attacked to such a degree that every remedy is useless.

A species of the same genus, but smaller (*A. paniceum*), attacks not only wood, but also books, herbaria, natural history collections, cork, dry bread, biscuits, etc.

The *Anobium pertinax* also is very injurious. Its specific name is due to its persistency in feigning death when it is seized. This simulation is such that when immersed in water, and even in alcohol, the insect remains perfectly immovable. It would rather allow itself to be burned alive than betray itself.—*La Nature.*

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